

JEWELS IN THE SKY



BINAYA KRUSHNA PATTANAYAK

JEWELS IN THE SKY

Presentation

Binaya Krushna Pattanayak

Composing

Intellectual Avenue, Bhubaneswar

Layout

Puspashree Pattnaik, Srujanika

Illustrations

Braja Kishore Jena

Binaya Krushna Pattanayak



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PREFACE.....

.....Still I feel the words in the title as inadequate. Jewels are quite attractive and precious to human beings. But they can not be compared with the stars in the sky. The twinkling little star with its surroundings simply mesmerises us. The clear dark night sky with its innumerable stars and other celestial bodies is a dream-beauty and eternal inspiration to all of us. Millions of bright jewels seem to be glowing and saying something with a dark screen on the background. Besides, the new patterns appearing on the screen from time to time make it a great show for the spellbound observer.

The articles in this book might seem to be quite diverse like night sky. I have not created any new idea or any new content except my own way of presentation. I feel, Astronomy is an unending fun. I have enjoyed a little of that. But I have derived great pleasure in this little attempt. I am convinced that the interest, sense of appreciation and curiosity of a person guides her/him to swim across the ocean of knowledge, light and strength which are so to say the basis of life.

The talk on "Why the sky is blue" by the late Prof. C. V. Raman not only explains the colour of the sky, but inspires us also to culture a true scientific attitude and confidence. Hope this would be a guiding spirit to all the readers.

I am grateful to Puspashree Pattnaik and Dr. Nikhil Mohan Pattnaik of Srujanika and Subhendu Pattnaik of Intellectual Avenue for their help in preparing the book. Braja Kishore Jena helped a lot in doing the illustrations. Asis Mukherjee of CIAA has extended his full cooperation for its publication.

14/1/1995,
(Makara Sankranti)
Bhubaneswar

Binaya Krushna Pattanayak,
(Organising Secretary)
C.I.A.A.

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Whoever wishes,
May he sit in meditation
With eyes closed
To verify if the Universe be true or false.

I, in the meanwhile,
Shall sit with insatiate eyes
To see the Universe
While the light lasts.

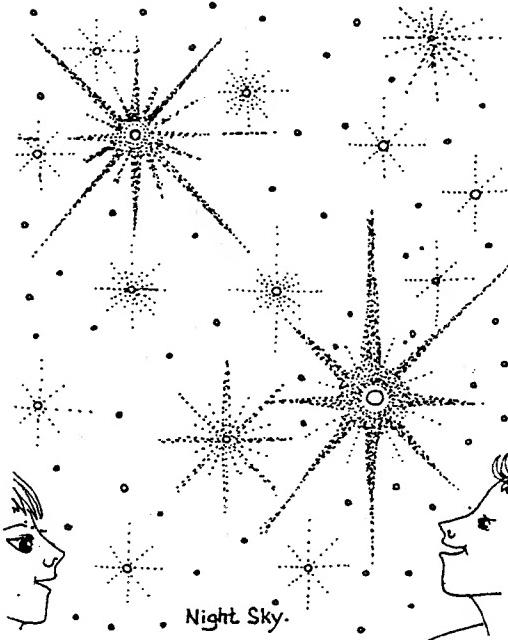
-Rabindranath Tagore.

OUR PLACE IN THE UNIVERSE

U..n..i..v..e..r..s..e.. When we think about it, many thoughts come to mind.

- What is the Universe ?
- Who more are there in this ?
- How big are they ?
- Is there life on any other planets ?
- Where does the Universe end ?....

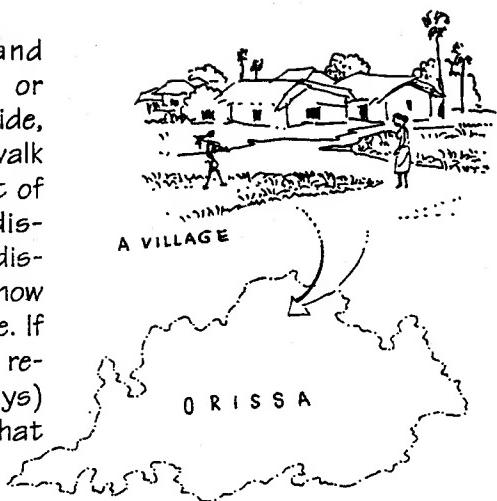
It continues. Many questions come to mind. It turns out to be more and more mysterious ! But one thing is sure that it is full of beauties and diversities. Whether we understand it or not, yet one gets enormous



fun and excitement. The more is the search to understand, the more it becomes enjoyable. Let us start searching, enquiring and analysing - thereby enjoying the fun.

Let us start with ourselves. We all are humans. We are having homes of our own. We have our father, mother, brothers and sisters. We call this a family. When a letter comes to us the address has our name on the first line. Next comes the plot Number. Followed by the name of the Colony or Street, where we have many houses and many families. The size has increased considerably since we started. Can you compare the size ? Suppose the school is 1 K.M. away from home. How long do you take to walk down ? 15 minutes? Then your speed comes to 4 kilometres per hour. This can help us in measuring the length of different places. Let us move ahead in our venture.

A lot of colonies and streets constitute a village or town. If the village is 4 k.m. wide, how long you would take to walk across? Nearly one hour. A lot of villages and towns make it a district. A definite number of districts make it a state. We know the name and size of our state. If it is 400 k.ms. wide, we would require 100 hours (nearly 4 days) to walk across at a stretch. What comes next?



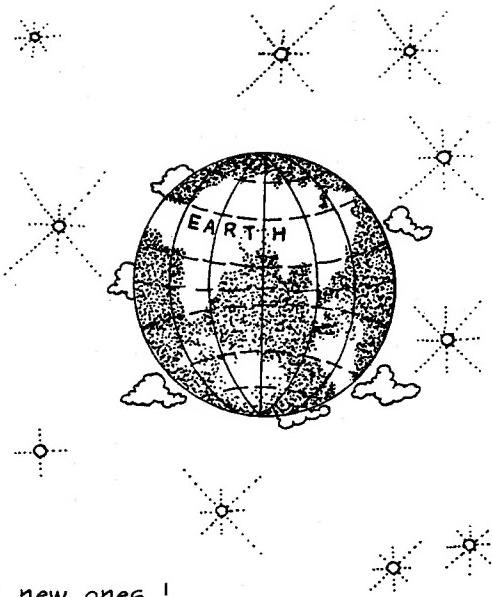
We know that 26 such states and the 6 Union Territories make India a vast country. India is a beautiful land with enormous flora, fauna, natural resources, people of different tastes and life styles. This is a unique country and a symbol of unity in diversity. The Northern region is decorated by the gigantic and snow-covered Himalayas. The southern part is encompassed by Arabian Sea, the Bay of Bengal and the Indian Ocean. Srilanka is there on its right. How big is India? From the Himalayas in the North to Kanyakumari

in the south it is nearly 4000 k.ms. long. It would take us 1000 hours or one and half months if we just walk and walk without a break. You might be getting excited to be on this venture. What next?

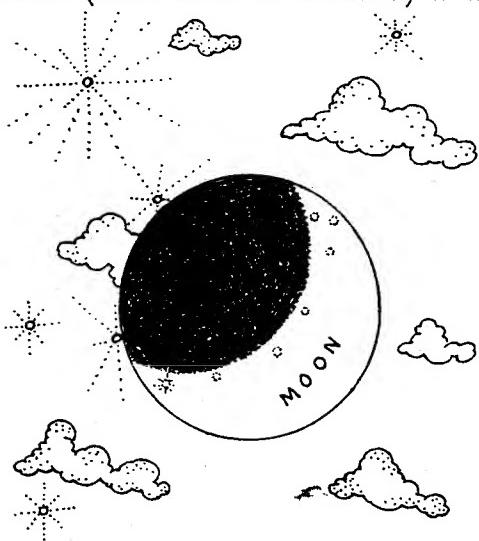


More than a hundred countries like India who constitute a bigger land- the continent, i.e. Asia. It turns out to be the largest continent. There are seven continents and five oceans which make the Earth.

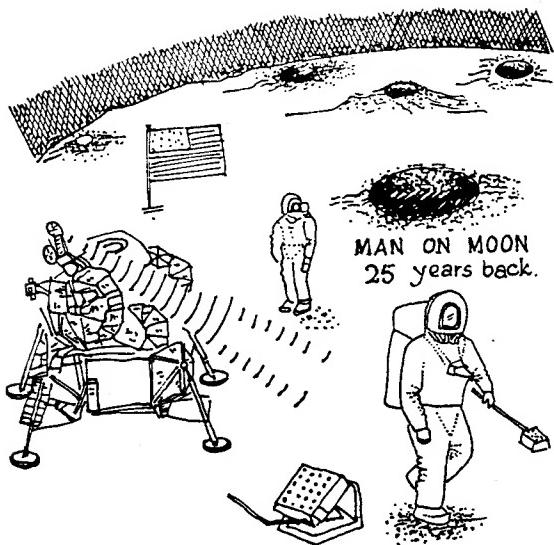
The Earth to us looks like full of uneven lands, mountains, trees, houses, rivers, people, animals, birds etc. But a bird's eye-view finds a different picture. From the sky, the earth is a colourful spherical ball floating and rotating in the vacuum. Can you imagine a great ball floating in the sky without being tied to any other thing ? But it is a reality with the earth. Another beauty is the Life on Earth. So many different animals, birds, trees and herbs changing their shapes, sizes, motion and are developing new ones !



How big is the Earth ? It is nearly 40,000 kilometres at its equator. would you like to have a walk ? It would take nearly 10,000 hours (Less than 15 months) if we walk unstopped.



We would look beyond this. Beyond the Earth if we search around, at first we would meet its nearby Moon. Almost everybody among us- from the little child to the old, like the moon very much. Its cool and soothing effect along with its changing patterns make it a show-piece. It is nearly 4 lakhs kilometres away from the Earth. We would take 1 lakh hours or nearly 12 years to walk over to the moon. Now you might be feeling a bit disheartened to

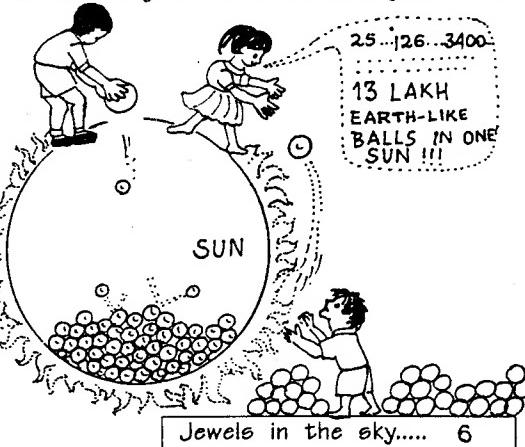


the phases of the earth, the Full Earth and the New Earth. The earth would have looked like the moon in our sky, but very colourful. Let us look beyond the moon.

The Sun.... everyday we see the bright sun in our sky. We enjoy the beauty of sunrise and sunset. It is the closest star to our earth. The distance comes to nearly fifteen crores kilometres. Walking across to the sun would take more than 4000 years ! Surprised ? But remember - it is the closest star to the Earth. Sun is a middle aged small star in the sky. A 500 million year old. If we would put balls like Earth into the sun, it would require 13 lakh balls to fill up the sun.

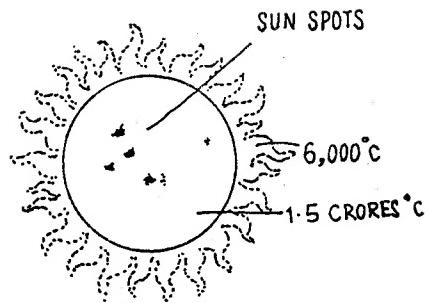
We know that the sun is a gaseous ball. Light gases like Hydrogen undergo nuclear fusion all the time to form bit heavier Helium gases. This nuclear transformation generates tremendous energy. It gets radiated in all

walk and walk and walk for 12 long years. But our fellow humans have reached the moon, of course, by other ways. Twentyfive years back, on 20th July 1969, American astronomers Neil Armstrong, Aldrin and Collins landed on the moon. It was a remarkable achievement ! To them sky was not blue, but was completely dark due to absense of air. They might have found another sight very fascinating. That is our Earth from the moon. From there one can see



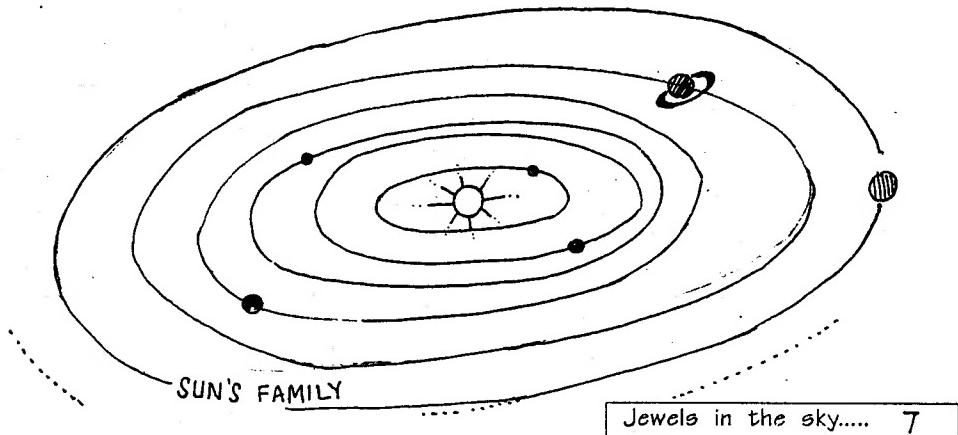
directions in the form of light and heat. Our Earth gets only 0.000,00,0005% of the total production.

Surface of the sun is 6000°C hot, whereas the inside is nearly 1.5 Crores $^{\circ}\text{C}$ hot. It has flames also. The size of the earth is negligible in comparision to these solar flares.



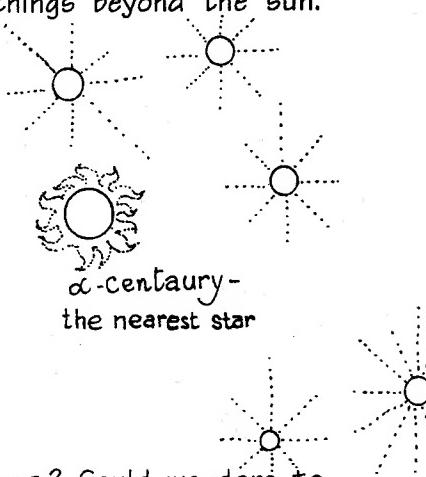
Although the sun looks quite bright and spotless, yet good photographs show black marks on its surface. These are the Sun spots, which are comparatively the cooler parts. Cool means some thousand degrees but cooler in comparison to the sun's surface temperature of 6000°C .

The Sun has a family. Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune and Pluto, their satellites, comets, asteroids, and meteorites - all constitute the Solar Family. Mercury and venus being the closer planets are very hot and stoney. Mars, Jupiter and Saturn in the list are quite distant to the sun and are very cool.

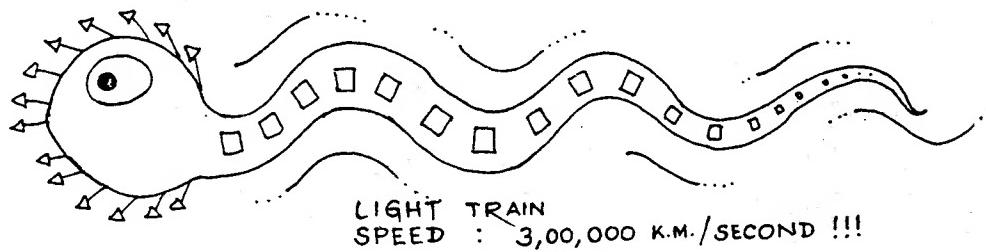


Earth is at a middle position which is neither too hot nor too cold. It has a pleasant temperature. The air, water and the soil have a very salubrious situation and have made the way for "Life", which is a unique feature on the earth. The sun plays a major role in controlling the atmosphere and other parameters on the different planets. It is the Sun's Gravitational pull that keeps all planets on their track. Now let us consider the other things beyond the sun.

After the sun, the closest constellation to Earth is Centaures. α -Centaury being the closest is at a distance of 42,000,000,000,000 kilometres. How do we read it? Forty two lakh crores of kilometres or forty two trillion kilometres. It looks like quite a big number but distancewise it is the closest star to earth after the sun.



How do we measure such large distances? Could we dare to walk this distance? Obviously not. We can not use the compass scale or, a measuring tape. But there is a way to find out this. It



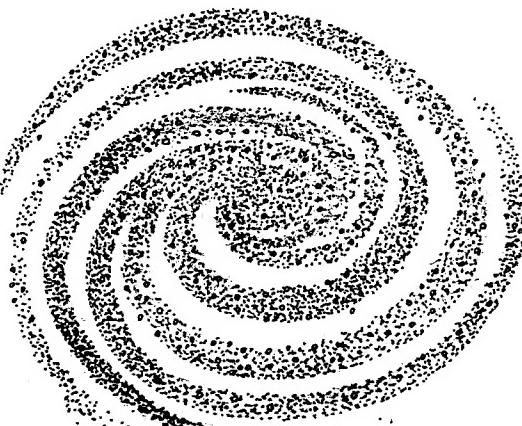
is LIGHT that measures all these large distances. It runs at a speed of 3 lakhs kilometres per second to any place in the vacuum and helps us in knowing the distances. Let us do a simple calculation.

In one second light moves 3 lakhs kilometers.
 In one minute ; $(3 \text{ lakhs} \times 60)$ kilometers.
 In one hour ; $(3 \text{ lakhs} \times 60 \times 60)$ km.
 In one day ; $(3 \text{ lakhs} \times 60 \times 60 \times 24)$ km.
 In one year ; $(3 \text{ lakhs} \times 60 \times 60 \times 24 \times 365)$ km.
 ~ 10 lakhs crores km.

This distance is taken as a unit and is called a "Light Year", i.e., the distance light travels in a year. This way we find that light from α -Centauri takes little more than 4 years to reach the earth; hence we can say that α -Centauri is little more than 4 light years away from us. Similarly, the Sun is eight light minutes away from us.

The Sun, α -Centauri etc. form a very small part of another big group. This is Akashganga or Milkyway Galaxy. In winter, we find a long cluster of stars across North-South in our sky. This is the Milkyway Galaxy. Major stars we see in our sky belong to this galaxy. It is quite big in size. Light takes a lakh years to go from one end to its other end.

This is also quite nice looking. From the top side it looks like a "whirlpool". You might be surprised on knowing the shape and size of this galaxy. Our solar system is only sixty four croreth of the Milkyway galaxy and our home-the earth is only 25 thousand croreth part of the solar system. There are millions of stars of various magnitude, colour, age and stage in this galaxy. Is there any thing beyond the Milkyway galaxy ?

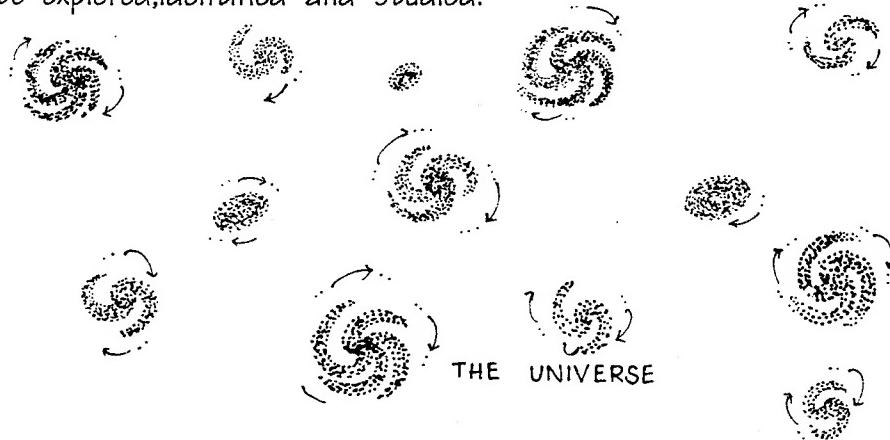


MILKY WAY GALAXY
A BEAUTY--A JOY !

Yes. Millions of galaxies are there all around the Milkyway galaxy. They are of different shape, size, age and contents. Among them the closest galaxy to ours is the Andromeda galaxy. It is at a distance of 20 lakh light years from us. The light which enables us to identify Andromeda in the sky might have left Andromeda 20 lakh

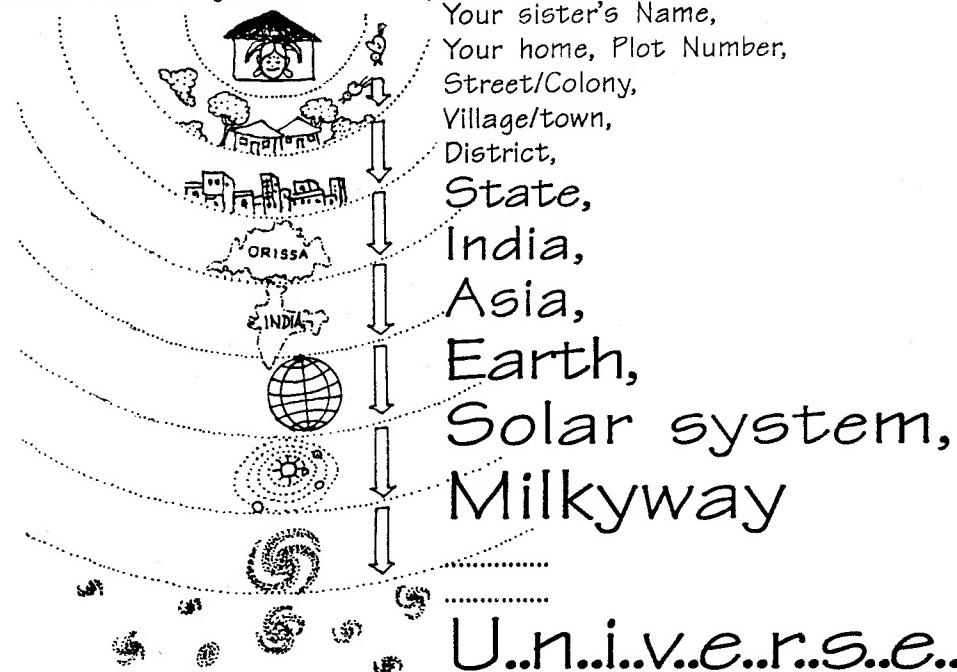
of years back. If Andromeda vanishes out from the sky, naked eye watching would be able to know the incident only after 20 lakh years, but there are other methods to know about it.

All these millions of galaxies make a great system. That is beyond humans imagination even. This is the U...N....I...V...E...R...S...E... Whatever we know till date are a part of this and what more we will be able to know will also be part of this. It is endlessinfinite. From its imaginary centre to the farthest identified galaxy the distance is supposed to be 1000 crores light years. There are lot more to be explored,identified and studied.



Our long cosmic voyage has enabled us to move from ourselves and our little sweet home to our gigantic lovely home named the Universe.

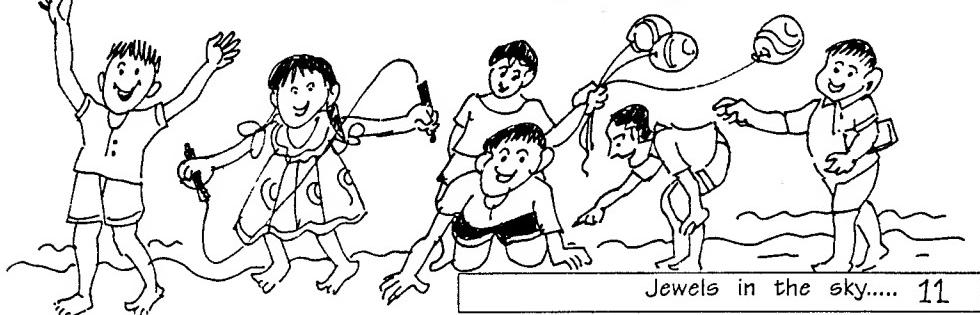
Now you must be getting tempted to write a letter to your home. But, do you remember your address now? Let us write it.



U..n..i..v..e..r..s..e..

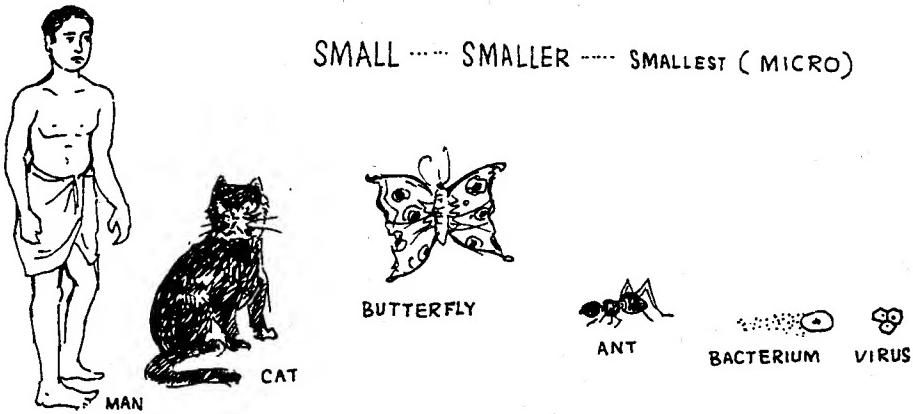
Now if we think about our place in the Universe, we will feel quite awkward. How small are we in this infinitely large universe! But think. Very strangely we, the tiny things in this endless universe, still indulge in quarrelling and in talking ill of each other! In this mysterious and beautiful universe, Life is too short a span to explore and enjoy it. It can be said:

"One who understands the vastness of the Universe forgets egoism."



It comes to mind that how small we are really in this Universe! But let us think the other way. Are we really the smallest? Then what about the cat, butterflies and ants? They are quite smaller.

Smaller to them are the microbes like bacteria. One thousandth of a millimeter. We measure them in micrometers. They can not be seen in naked eye. We need microscopes. Sometimes they create problems for us. Diseases like typhoid, cholera, tuberculosis etc. are caused by them. But without them we can not enjoy a glass of curd or lassi nor can we find garden compost. All dirts from our home and garden are being decomposed by these microbes in a natural way.



Smaller to them are the Viruses. They can be kept in bottles for years. They would not die away. Once they get a salubrious atmosphere, they would again flourish and multiply. They create diseases of various types. No medicines till now have been developed for treating these viral infections.

Is there anything still smaller? Yes. The Molecules. A common microscope fails to identify these. A methane or, ammonium ion measures ten croreth of a centimeter (angstrom unit needed). Atoms constitute these different molecules. They are the smallest part of any matter: the tree, the mountain, the star or your body. The whole universe is composed of these atoms of differ-

ent types. Even atoms can also be divided. The electrons, protons and neutrons. These are the Fundamental particles. All things are made up of atoms and all atoms are made up of these fundamental particles in different proportions. Among these the electrons are the smallest.

Such an interesting voyage from the micro to the macro world might have fascinated you. Have you realised your place in the whole universe ? In this vast and endless Universe, a thing however big or small, has its own identity and a definite duty also. Let us all enjoy the fun in this exciting cosmic voyage and join hands to create ways for everybody's happiness, peace and laughter.



COSMIC CALENDAR

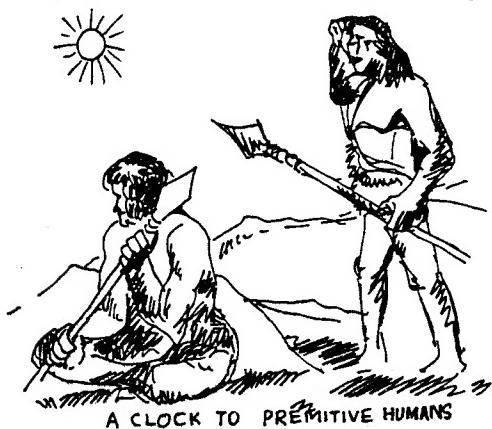
It is estimated that the Universe began with the Big Bang 1500 crores years back . Let us assume this span of time to be equivalent to one calendar year . Then 1 second will be equivalent to 475 years . Then we can find out the chronology of some of the remarkable changes which have occurred over the period .

- | | |
|----------------------------|----------------------------------|
| January 1 : | Big Bang -Universe begins . |
| September 14 : | Origin of the Earth |
| September 25 : | Origin of Life on earth . |
| December 16 : | Insects appear on earth . |
| December 23 : | Big plants and reptiles appear . |
| December 31,
(10.30pm): | Human beings appear on earth . |

THE GREAT SEARCH

Our place in the Universe has let us know many mysterious and sensitizing aspects of the Universe with a comparative study of the different matters. History and development of all these ideas are equally exciting and inspiring. The long search has seen many incredible changes in opinions and proofs to reach this stage. It has taken the humans much more than 2000 years to understand the mystery in a broader way.

Have you looked at the sky ? what things do you find in it? The blue day sky, the bright sun, sometimes clouds, thunder, the rainbow, raindrops, the day & night, etc.. In the night thousands of jewel -like stars of so many variety twinkle in the dark sky. Sometimes the Moon also appears with changing shapes. All the nights it keeps on changing. It becomes difficult to understand why



A CLOCK TO PREMITIVE HUMANS



there are so many varieties ? Stars of different magnitudes, sizes, colours; planets and their satellites; Sun, Moon, different comets and meteors. Questions pour in in great number before you get satisfactory answers. Simultaneously , it becomes very fascinating to watch the beauty and diversities of the night sky. One fails to feel how much time

Jewels in the sky..... 14

has passed on. The more you look at it, the more you explore the real truth. It is not only us, but the sky and stars have attracted the attention of humans in all ages. Among different things the first thing that had fascinated primitive humans was starry nights the Sun and the Moon. Hence the science so developed, is supposed to be the oldest of all sciences. Not only oldest but most exciting also.

At that stage, they did not name them like Sun, Moon, Saptarshi or Orion. But they were observing the different sky objects quite enthusiastically. They realised that the Sun is quite bright. When it is in the sky they were able to see things around; they felt warm; most wild animals kept away. From one sunrise to the next sunrise, the gap was called a Day.

The Moon appeared to be of similar size but changed its shape every night. From one Full Moon to another, it took a long time. This gap they called a Month.



In stars, they also found some relations. The star rising in the eastern horizon after the Sun set, seemed to be going a bit higher in its position at the same time on the next day. Everyday it changed its position. It returned to the same spot at the sametime after quite a long interval. This gap was named a Year. This way the primitive people could device ways to keep account of time along with the fun of sky watching.

SUN → DAY

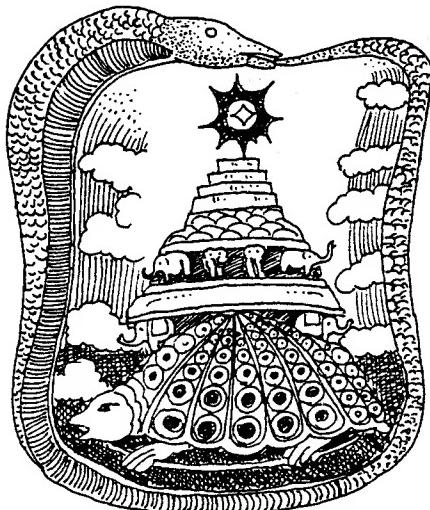
MOON → MONTH

STAR → YEAR

CLOCK AND CALENDAR AS PER THE MOVEMENT OF CELESTIAL BODIES

With the growth of Agriculture and civilizations, people started shifting towards river beds for cultivation and stable habitation. Major civilizations like Indus, Chinese, Babilonian, Egyptian, Mesopotamia etc. grew up. In all these civilizations people had their different imagina-

tions about the sky and the universe. The Egyptians viewed the sky as the Goddess 'Nut' with all stars studded to her body. The Sun, Moon and planets were supposed to be moving on boats across her body.



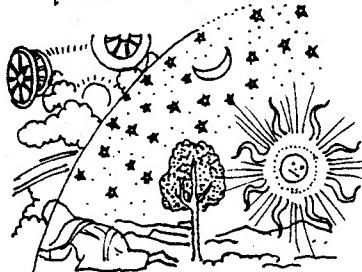
(INDIAN MYTHOLOGICAL VIEW)

The Greeks felt all stars, planets etc. are studded to the roof-like-sky. Machines are connected to this gigantic roof. The giants operate these machines. Hence the sky keeps on rotating.

These were all complete imaginations. But along with daily observations people started thinking logically. They felt- the Earth is at the centre and all other celestial objects go around it periodically. In the 2nd century the Greek scientist Claudius Ptolemy put forward the first model of the universe. The Earth remained at the



The Indians believed that the 'Vasuki Nag' has Lord Vishnu on its lap as a tortoise. There are elephants standing on his back. There remains a golden dish on these. The earth was imagined to be on this dish. Peculiarly, even now-a-days old people in the villages say that if the Vasuki Nag gets angry and knobs its head than there would be natural calamities like earthquakes etc. on the earth.



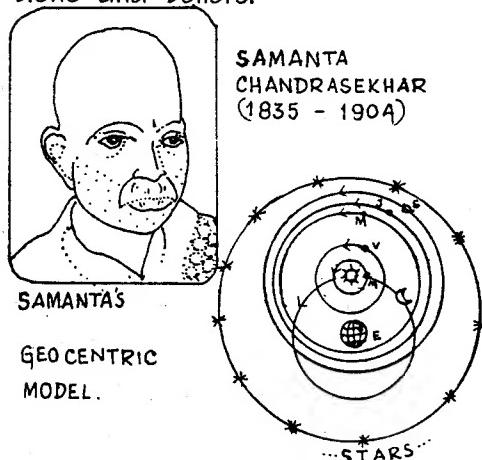
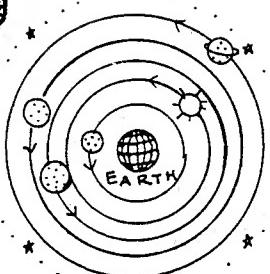
ANCIENT GREEK VIEW.

centre of this model. The Sun, Moon and the planets revolved around the earth in separate circular orbits. The stars were imagined outside those circular orbits studded to a glass sphere. The stationary earth was orbited by the Moon, Mercury, Venus, Sun, Mars, Jupiter, Saturn and the sphere of the fixed stars. This was a geocentric model. It found high appreciations all over the places. It could also explain the retrograde motion (sometimes backward) of the planets. The irregular motions of Mars and Venus were explained satisfactorily than everbefore. This model continued for a longtime. Indian astronomer Aryabhatta and Greek philosophers Aristarchus and Hipparchus had different views. They all believed that the Sun is at the centre of all. But they had no proofs to justify their beliefs. At that time the famous Greek philosopher Aristotle strongly established the Geo-centric theory by discarding all these assumptions and beliefs.



PTOLEMY
(90-168 A.D.)

GEO-CENTRIC MODEL



Gradually questions were raised against this assumption in the 15th century. Yet this geocentric model had been appreciated till the 19th century even in certain areas. Tycho Brahe of Holland in the 16th century and Pathani Samanta Chandrasekhar of Orissa in the 19th century believed in the geocentric model. Both Brahe and Pathani were great astro-

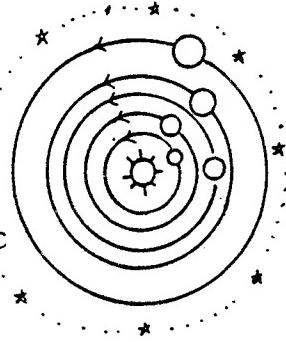
mers of their time. They believed that the Sun goes round the earth and all planets go around the Sun. The stars still remained outside. These theories in due course of time were revamped, but the great work done by these two astronomers was their calculations. Pathani Samanta - whatever calculations he had made regarding position of stars, their apparent movements, distance from earth, prediction of the different celestial phenomena like Solar and Lunar eclipses etc. were quite accurate. One more high point of Pathani Samanta's work was that he had no complicated or sophisticated instruments with him, but it was locally available bamboo sticks and wood which he used to calculate the celestial figures so precisely. Pathani's calculations are still in use in Orissan calendars and predictions.

In the fifteenth century, the geo-centric model was challenged by the polish astronomer, Nicolaus Copernicus (1473-1543) who changed the course of astronomy with one book, which he hesitated to publish for thirty six years. It was a remarkable peaceful scientific revolution. Copernicus built up a new model with the Sun at its centre and the planets going around it in circular orbits. The



COPERNICUS
(1473 - 1543)

HELIO-CENTRIC
MODEL.



stars remained fixed outside these orbits. This was a radical change in the geo-centric model. Instantly, the church, priests and conservative society got annoyed by this opinion and models.

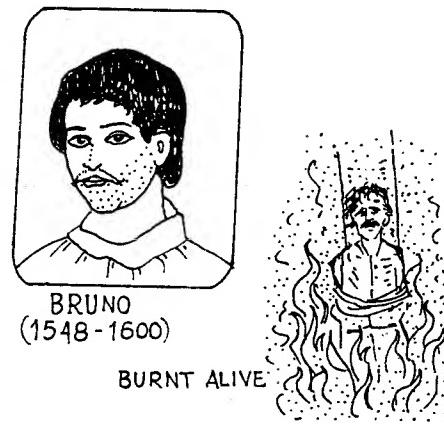
He was not allowed to publish his book "On the revolutions". His book could be published under a more specific title, " On the revolutions of the celestial spheres " in 1543. The first proofs reached Copernicus when he was quite weak and was on the death bed with fever. He also had suffered a stroke and was partially paralyzed. He was too weak to react to it. A few weeks later he breathed his last,

a few hours after he had received one of the first copies of his famous book. With the death of Copernicus, it seemed that his theory would die. He was hailed as a great astronomer, but his theory was ignored, even ridiculed.

Only one man believed in the Copernican model. He taught it, defended it courageously and died for it. It was Giordano Bruno who was born in a Italian farmer's family 5 years after Copernicus's death. He had an independent outlook. The 25 year old Bruno fell in love with the spirit of Copernicus's book.

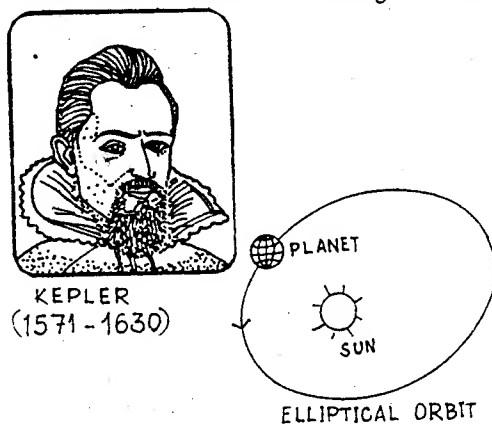
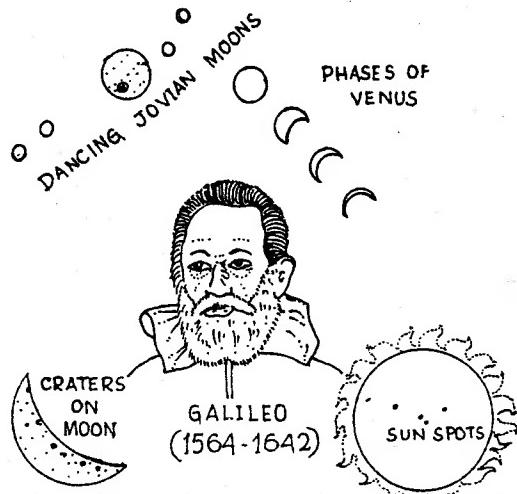
He left his priesthood and became a humanist - taught in colleges as an assistant professor. He hated the authoritarian view of Aristotle and the conservative attitude of church and priests. Bruno was like the founder of a universal religion. He was against the accepted authorities. He thundered against the "learned asses". Only an ass, he said, could have written the preface to the Copernican book for the benefit of other asses. This he was referring to the injustice done to the publication of Copernicus's book.

He travelled around England, France, Germany and taught about the Helio-centric model against all odds. Everywhere he found high appreciation and support of the people. The conservative society and church got irritated every time and searched for him. Finally he was caught by the irate church guys in Venice. He was on trial for seven years. He was condemned and insulted and was turned over to the secular arm. Still brave Bruno was bold and harsh. He did not change his remarks nor did he succumb to court's pressures. Ultimately, the extoller of Truth, Bruno was burnt alive on 17th February, 1600.



Bruno paid the supreme price not because of the support to helio-centric model, but for his free and independent religious views. But he laid a strong supportive foundation to the Copernican model and spirit. His assassination stunned his supporters. But gradually they picked up and a strong attempt built up in Europe to establish the truth.

Another champion from the same country (Italy) arose in the person of Galileo Galilei (1564 - 1642). Peculiarly, Galileo narrowly escaped a similar fate by recanting. He, by his logical arguments, experiments and observations laid strong support to the helio-centric model. He made the first telescope on earth. With own self-grinded glass lenses and tubes he made the new instrument. He showed the dancing satellites of Jupiter, the rings of saturn, the phases of Venus, the craters of the moon, and the changing positions of Sun spots. His proofs outdated most of the old wrong beliefs. He brought a new age in science. His telescopic discoveries opened the heavens to further investigations.



At the same period, German Astronomer Johannes Kepler made a significant contribution and explained the orbits in a simpler way. He calculated that the planet's orbit are not circular as described by Ptolemy, Copernicus or Brahe. But are Elliptic. Hence they appear to retrograde sometimes

although these are always forward motions only. He also explained the shapes of the orbits and the laws regarding rotation of planets around the sun.

Ultimately, it was the great English scientist, Issac Newton, who laid the finishing touch to these astronomical predictions and imaginations. He was born in England the year Galileo died. He established the Laws of Universal Gravitation and opined that all things in the universe attract each other. The force of attraction is proportional to the masses of the objects and inversely proportional to the distance between them.

This attraction balances the whole universe. This was the right answer to the rotation of the planets in elliptical orbits around the big sun.

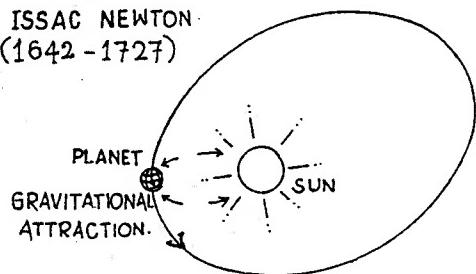
Newton had a great contribution to Astronomy and Science. He had told that if he saw further than other men, it was because he stood upon the shoulders of giants. He himself was a giant. Great scientists like Galileo and Kepler were also dwarfed by his innovations. They were able to show how the celestial bodies moved, but Newton explained their motions in terms of simple laws. A short while before his death Newton said : "I do not know what I may appear to the world; but to myself I seem to have been only like a boy, playing on the seashore, and diverting myself, in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me."

His contemporaries felt that Newton did not leave anything undiscovered. Alexander Pope has expressed this the following way:

Jewels in the sky..... 21



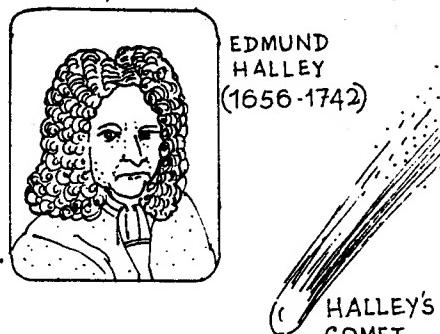
ISSAC NEWTON
(1642 - 1727)



"Nature and Nature's laws
 lay hid in night;
 God said, Let Newton be !
 ... and all was light."

.... It was a long search of much more than 2000 years that ultimately guided humans to understand the solar system. Newton attempted to explain about the other objects beyond the solar system even. He described that all stars are like the sun. They look so small because of their far distance from us. These scientific explanations about the Earth, moon, sun and planets were long appreciated and Newton was regarded as the leading scientist of the 20th century. But at his time methods were not there to measure the distances of the stars. Hence Newton was neither questioned nor was totally accepted on this point.

But Newton's friend Edmund Halley (1656 - 1742), the discoverer of the famous Halley's comet) initiated the measurements. He observed the changes in positions of several stars which was not known till then. It was realised that man's life span is quite short to feel the movement of the stars.

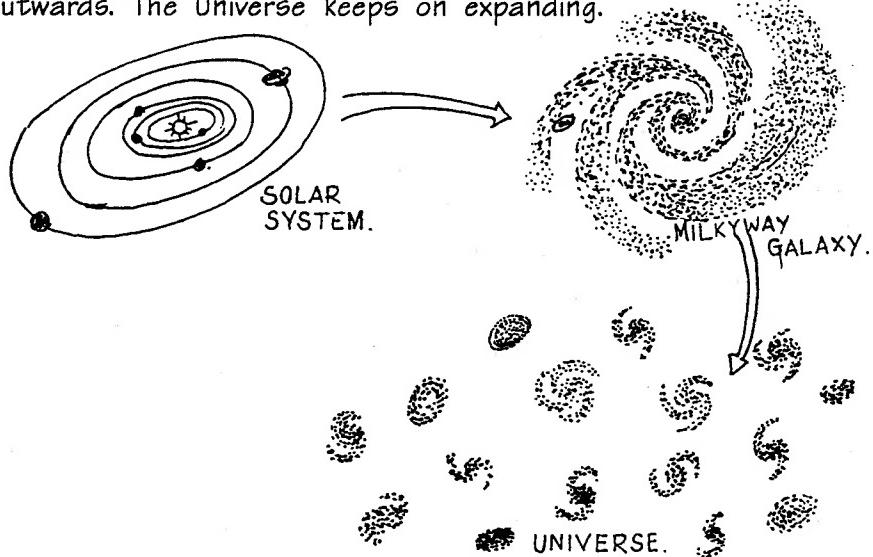


EDMUND
HALLEY
(1656-1742)

HALLEY'S
COMET

English astronomer William Herschel discovered many more stars around the solar system. He felt their densities to be more when near the sun and seem to lessen as we move outwards. By 1917 it was realised that the solar family although quite big is still a small part of a cluster of stars. It was called a Galaxy, i.e., system of millions of stars. Our galaxy was called the Milky way galaxy. Most of the stars we find in our night sky are part of this galaxy. Herschel also deduced a formula to calculate the sizes of the galaxies. By 1923 it was found that the milkyway Galaxy is not the end of our celestial system. There are thousands of galaxies all

around. They constitute the 'Universe' - which is said to be endless. Man has not known the territory of the universe. Another surprising fact about the universe is its expansion. It has been known that all galaxies are rotating and moving at great speed. Milkyway galaxy rotates at a speed of 10 lakhs kilometers per hour and simultaneously recedes away from its original position at high speed. This way all galaxies seem to be moving away from the imaginary centre outwards. The Universe keeps on expanding.



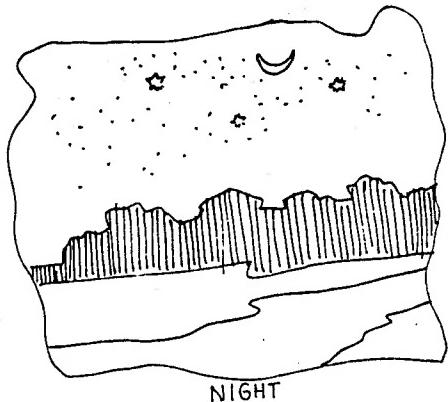
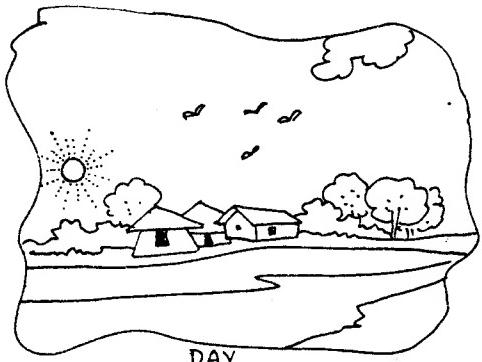
It was a long and collective search of the humans through different ages. Over these 2000 years humans have realised the shape of the Universe in a broadway. But still it is equally mysterious and challenging. Every moment we are discovering surprising facts and events and are unveiling the mysteries about it. Nobody can deny that the present ideas about the Universe would undergo radical changes after some new discoveries and calculations. Even then it would be much more mysterious and enjoyable.



JEWELS IN THE SKY

The sky above us looks continuous in all directions - from the four corners on the horizons to the top on the head. It resembles in shape a big bowl turned upside down or an open umbrella. A clear day sky looks blue with the bright sun shining throughout the day. It is nothing but sun lit air. Sometimes clouds make it grey and white. The air scatters the blue colour of the sunlight in all directions. If we would move beyond the atmosphere, the blue colour would turn dark. Only the sunlit earth, along with the bright sun and other stars would be visible in the darkness.

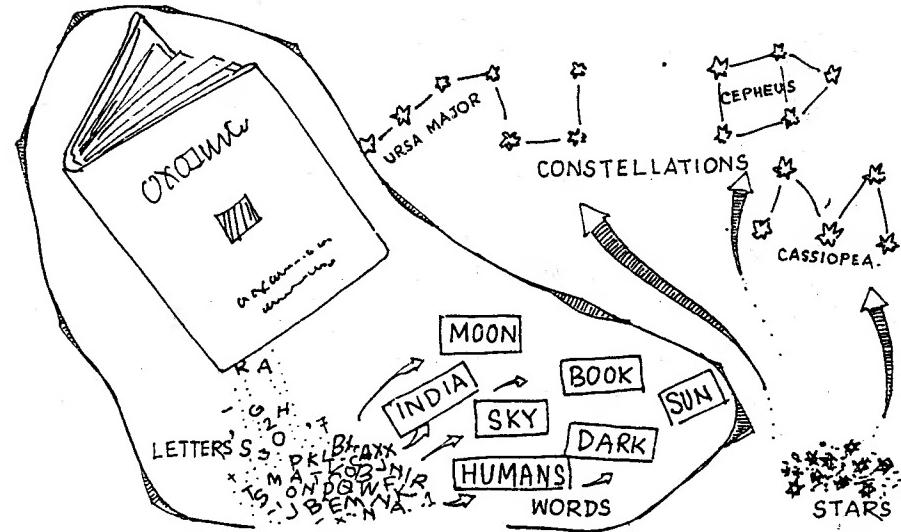
As the sun sets the sky colour starts changing. If the moon is there the air again scatters the moon and star lights, but still it looks bit dark. If the moon is absent the night sky looks quite dark and thousands of stars of varying size, colour and brightness twinkle all over.



A glance at the night sky is quite fascinating. The stars look like jewels studded all around. The inquisitive mind fills with so many querries. Since our early childhood, when our mothers had shown us the bright moon introducing it us our 'uncle' the appreciation grows for the sky objects. It grows and grows till one dies.

Humans have admired the sky for centuries. It was a clock and calendar to the ancient people. They could see more than 3000 stars in naked eye. But the problem was how to recognize them. The night sky pictures kept on changing throughout the nights.

Let us consider this book. It contains thousands of letters. If all are placed randomly on a table it would be somewhat like a night sky. It will be difficult to remember any of them. But through different patterns and arrangements we have compiled a specific book. Similarly, to remember the random arrays of stars, they organised the patterns in the sky. They identified nearby bright stars and grouped them to form different constellations.



Along with the change in concepts about the Universe, through the ages, these classifications of stars also changed. Finally, the constellations of different patterns were standardised and were accepted all over the world.

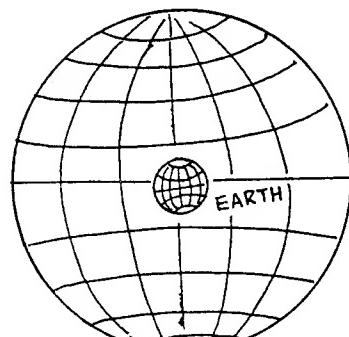
The sky above us looks semispherical in nature. If we conceive the sky down the other side of the earth, we would find the sky as a spherical ball around the earth. The spherical earth would be at the centre of this spherical transparent ball. The stars although are at different distances from the earth, still, from the earth they

would seem to be fixed on the outer sphere. This is called the 'celestial sphere'. We call this the Khagol Mandal (Kha-sky; gol-sphere).

We are familiar with 'Bhugol' (geography; Bhu-Earth; gol-sphere). By reading Bhugol, we know about the Earth, its different parts, its beginning, its atmosphere, the inside and surface in detail. Similarly 'Khagol' guides us to understand the sky above us in detail. We can know what are the bright objects in the sky, what and where are they precisely, how to locate them, the history of astronomy, its development, the fun behind night sky watching and lot more. All it makes this the oldest and most exciting science of Astronomy.



EARTH GLOBE



KHAGOL MANDAL

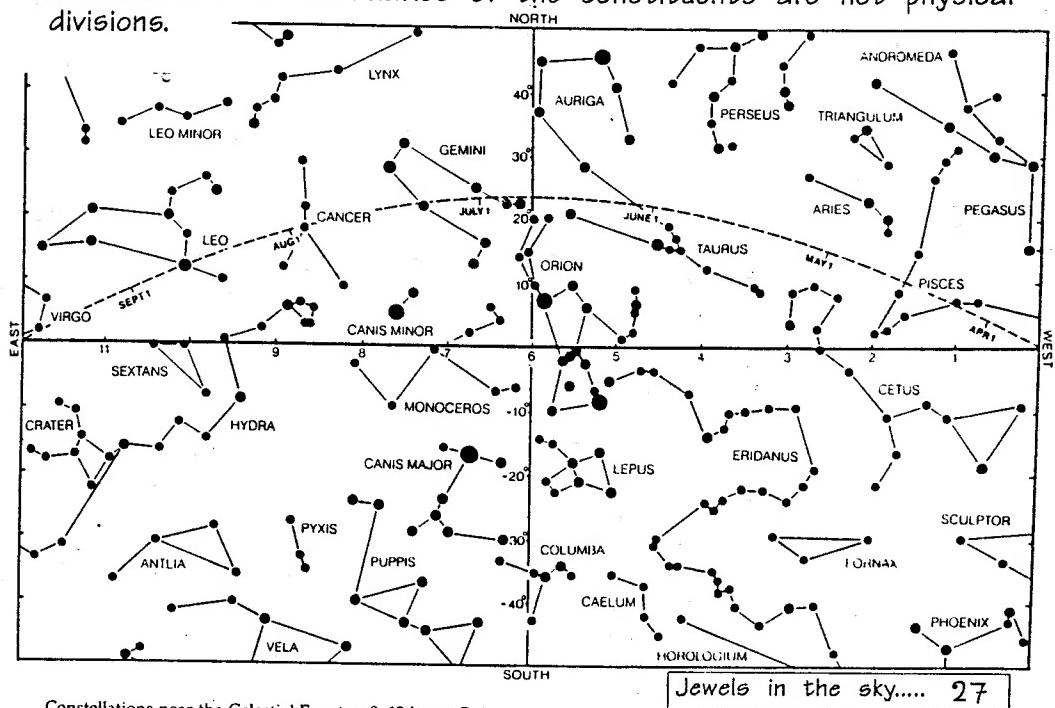
In Bhugol we look at the earth as a solid spherical ball. In Khagol also, we look at the celestial sphere to be a gigantic ball circumscribing the earth ball. It is like two balls - the tiny one being at the centre of the giant one. All celestial bodies like stars, planets, comets etc. are imagined to be twinkling to us from this outer sphere. Actually, they are not fixed to this, but a person looking at the sky feels like that.

Ancient people did not know which is what. They classified them according to their brightness, colour, size and time of appearance. Their life styles were oriented according to their positions and appearance. The Sun, Moon and stars helped them in understanding time throughout the year. They distributed their works accordingly. Nearby bright stars kept on maintaining a fixed distance among

each other. Humans imagined these shapes to be of different things—birds, animals, different human beings and different other forms. People in different areas interpreted these figures in different ways. The seven stars pointing to the polaris were called 'Saptarshi' in India whereas it was interpreted, by the western observers as the tail of a 'big bear'.

It was purely observation, imagination and interpretations. These imaginations filled the open sky with lot of funny figures. Different names and stories for each such constellation made this topic quite fascinating to all types of people all over the world. Thus grew the oldest science of Astronomy with contribution of all types of skylovers. It turned out to be most popular also.

Altogether it came to 88 such constillations, which was accepted by people the world over, but with different names and story interpretations. It is like dividing a continent into countries and states. The boundaries of the constituents are not physical divisions.

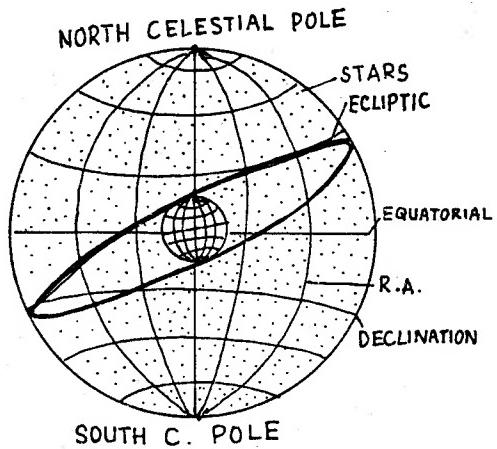


Constellations near the Celestial Equator: 0-12 hours R.A.

Khagol Bigyan (Astronomy) enables us to know all these interpretations and their genesis. How do we start with? In Bhugol, we start with a globe, i.e. a small model of the Earth. We find different colours, boundaries and district lines which represent different places, their boundaries, locations etc. We refer to some coordinates to locate any place on earth.

At first we find out the different corners on the globe and the poles - top being the North and South being its opposite side. The right hand side represents east corner and the left side points to the west of the globe. Then we find the globe being equally divided at the middle of the two poles. The horizontal straight line of this division is the Equator. Similar horizontal circular lines are drawn parallel to this equator on either side and they continue up to both poles. These lines are called "Latitudes". Similarly there are some vertical lines also which touch the two poles at their ends and cut the Equator at equal distances. They are called the "Longitudes". These all are only imaginary lines conceived on the spherical earth. They serve as the coordinates to identify any place on the earth. Let us consider India. India lies on the earth between 20° and 40° away from the equator towards north-east.

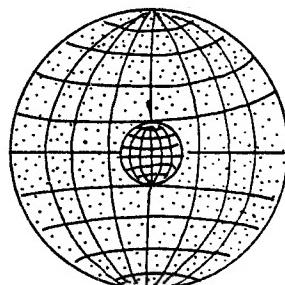
Any body referring to these coordinates finds India instantly and accurately. We can locate our small and unknown village on the globe through these coordinates. Accordingly, the physical, social, economical and cultural details of most places on earth have been studied. Thus a small handmap opens up our way onto any place on earth and the subject of Geography guides us about the whole Earth in a complete way.



It is the same with Khagol also. Imaginary lines and points have been marked on the celestial sphere which guides us to locate and understand most stars in the sky. We can have a comparative table the following way :



EARTH GLOBE



KHAGOL MANDAL

**Geography
(Bhugol)**

- | | | |
|---------------------------------------|-----|--|
| 1. North Pole (<i>Uttar Meru</i>) | ... | Celestial North Pole
(<i>Khagol Uttar Meru</i>) |
| 2. South Pole (<i>Dakshin Meru</i>) | ... | Celestial South Pole
(<i>Khagol Dakshin Meru</i>) |
| 3. Equator (<i>Visuv Rekha</i>) | ... | Celestial Equator/Equatorial
(<i>Khagol Vishuv Rekha</i>) |
| 4. Latitude (<i>Akshyansha</i>) | ... | Declination (<i>Kranti</i>) |
| 5. Longitude (<i>Draghima</i>) | ... | Right Ascension (<i>Dhruva</i>) |

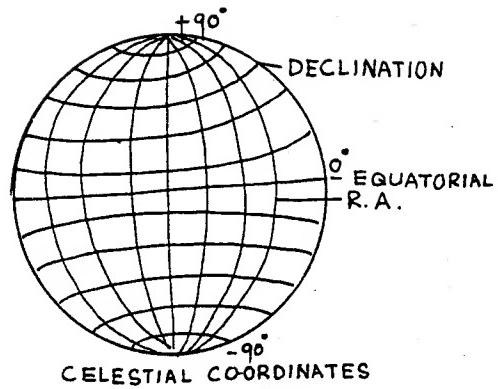
**Astronomy
(Khagol)**

The celestial coordinate system for stars is done by projecting the earth's Latitude and longitude coordinates onto the sky. Let us discuss the celestial system :

The Pole : The points on the celestial sphere exactly above the earth's north pole and south pole are respectively the celestial

North Pole and celestial South pole.

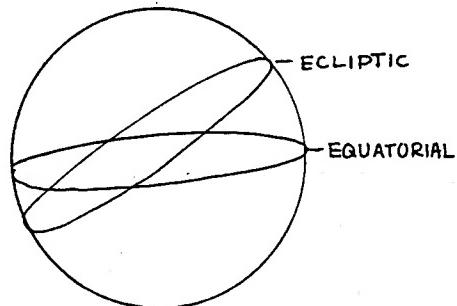
Declination : This is equivalent to the earth's latitudes. It is measured in degrees north or south of the celestial equator. The declination of a star on the celestial equator is 0° . This goes up as we move towards the celestial north pole. On the north pole it would read $+90^\circ$. The same way, it descends down the equatorial till the celestial South Pole, where it reads -90° .



Right Ascension (R.A.) : This corresponds to earth's lines of "Longitudes". These lines between the North and South Poles cut the Equatorial at equal distances at right angles. On the earth, the reference point for longitude is Greenwich, England. The corresponding reference point for R.A is the Sun's position of crossing the Equatorial in Spring season (Vernal Equinox). This marks the location of Zero R.A. From there, as we move towards the East the different coordinates read R.A. equal to 1 hour, 2 hours, 3 hours, till the 24th or Zero hour. The earth takes 24 hours to cover its rotation of 360° . Accordingly the R.A. has 24 hour coordinates in covering the whole of the sphere.

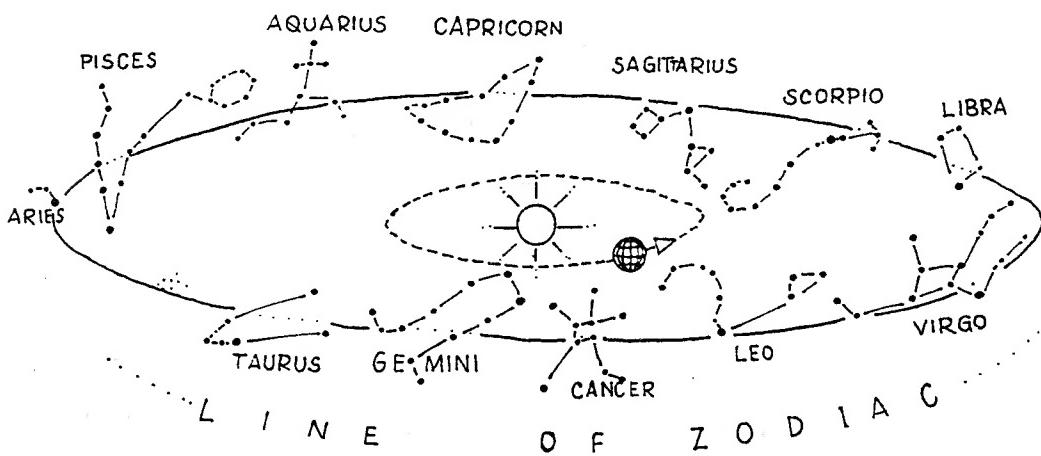
The Equatorial : The line on the celestial sphere exactly in line with the earth's equatorial line is the celestial equator or, Equatorial.

The Ecliptic : This is an imaginary circle on the celestial sphere making an angle



of $23\frac{1}{2}^{\circ}$ with the equatorial. This is the path through which all planets, moon etc. move around the sun. But in our sky, the sun seems to move from East to West every day. In one year, the sun seems to have covered one circle around the earth. Actually, this all seems this way due to the revolution of earth around the sun. In our sky, ecliptic can easily be located. The sun, moon and all planets move in the sky in this path. Because of the inclination of the axis of the earth the ecliptic is not coincident with the equatorial, but is at an angle of $23\frac{1}{2}^{\circ}$ with it.

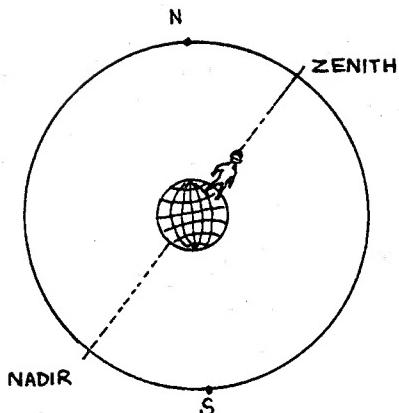
Line of Zodiac: The ecliptic is also called the line of zodiac. Along this line there lie 12 prominent constellations. They are called Zodiac signs. The Ecliptic is nearly equally divided into 12 regions (each of 30° distance) referring to these 12 Zodiac signs. The sun while arbitrarily moving across the ecliptic seems to spend a month in each zodiac sign.



These coordinates remain the same for an observer on any part of the earth. But there are some more celestial reference terms which vary for different places on earth. They are :

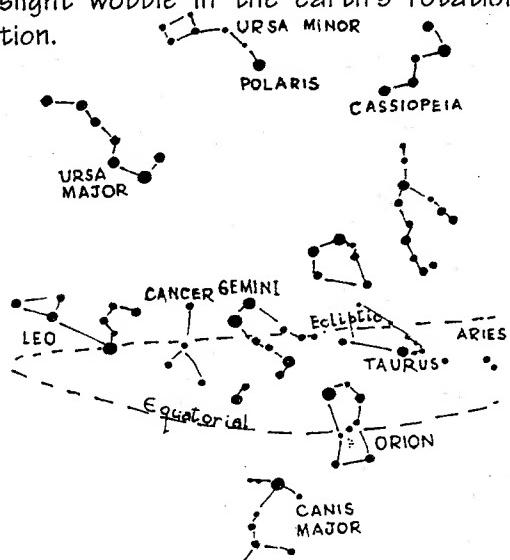
Zenith : This varies from place to place. The point right over the head of an observer at any place is called the Zenith.

Nadir : The point facing exactly opposite to the Zenith is Nadir for that place. Simply saying, if a person stands straight, the point over the top of his head on the sky should be Zenith whereas the point exactly down his feet on the opposite side of the celestial sphere would be his Nadir.



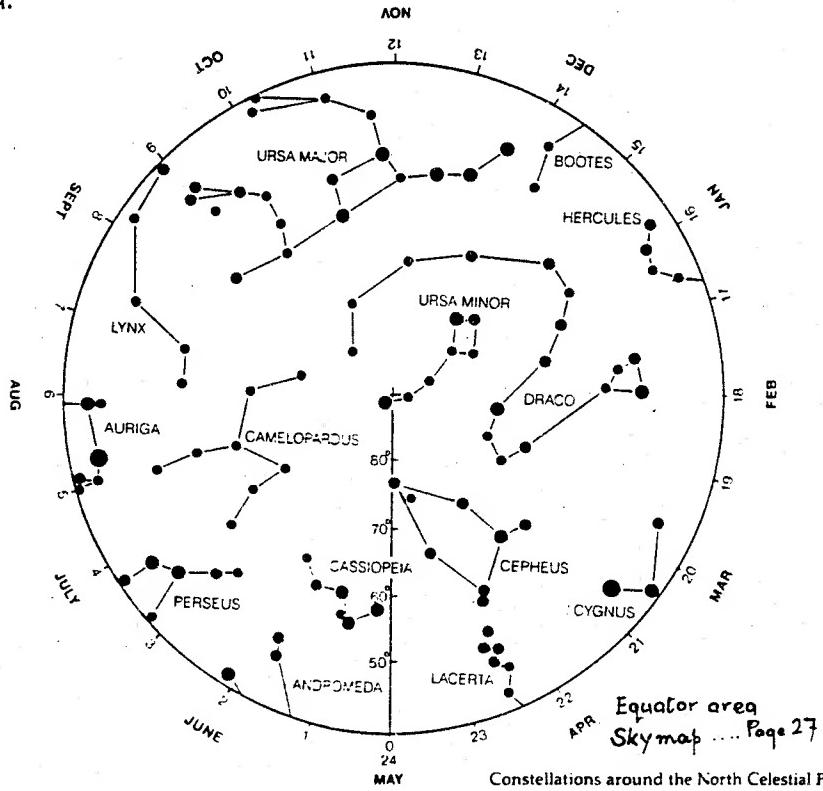
Meridian: This is an imaginary line across the sky from North to South passing through the Pole star and Zenith. This is also a variable line through which all the stars cross overnight. The time a star crosses the Meridian, that is its highest point and is called the time of "culmination" of the star.

There is a major difference between the surface coordinate system of the earth and the celestial sphere. The celestial coordinates have been devised according to the Earth's rotation. Hence a slight wobble in the earth's rotation disturbs the whole interpretation.



Star charts : In Bhugol (geography) we use maps. The spherical Earth is being drawn on plain papers. It becomes 2-dimensional presentations of the 3 -dimensional object. In Khagol, it is quite similar. Sky maps for different places have been drawn. The main problem lies in transferring the stars and constellations on

a 3-d surface to a 2-d plain surface. If the cover of an orange is cut open it would not be possible to match it on a plain surface. It will bear some wrinkles and faults. If the two ends are bit stretched then it may be bit more flat. Similarly if we try to put the celestial sphere on to a plain surface with little stretching, then there will be some problems. The shapes of the polar constellations will be distorted. Hence generally the polar regions ($\pm 60^\circ$ to $\pm 90^\circ$) are separated from the middle portion. This way has proved to be more accurate. Star maps of different shapes and types have been designed.

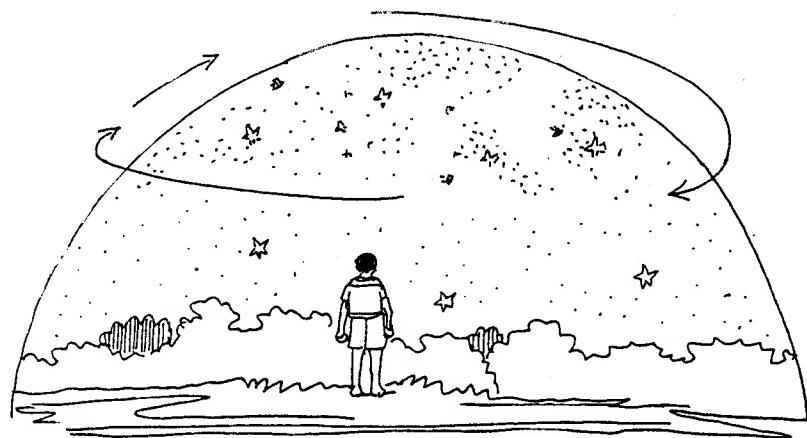


One can identify the different stars, constellations and mete-
orites, etc. by referring to these maps. This requires little practice
and regular observation. With experience one sees the stars and
constellations quite prominently. Gradually it becomes really exciting.

As the sun sets, the sky is filled with varieties of stars. As time rolls on, stars seem to be moving towards the western horizon. This apparent motion is basically due to the rotation of earth. While moving apparently the stars maintain a fixed distance from the pole star. New stars keep on rising on the eastern horizon and stars on western horizon keep on setting throughout the night. The whole sky seem to be rotating all the time. The star dials are designed in such a way that they give the pictures of the sky at different times. When one observes the sky regularly then she/he can feel the orderly motion of the stars and can study the whole sky. In India we cannot see the stars near the south pole, because India is located 10° - 30° away from the equator towards north of Earth.



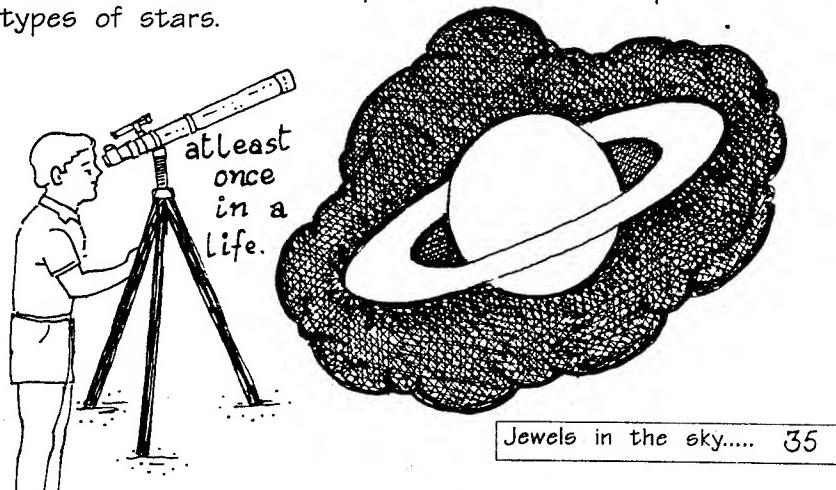
SKY ROTATES LIKE AN UMBRELLA POINTING TO POLARIS



SKY ROTATION OVER THE NORTH POLE

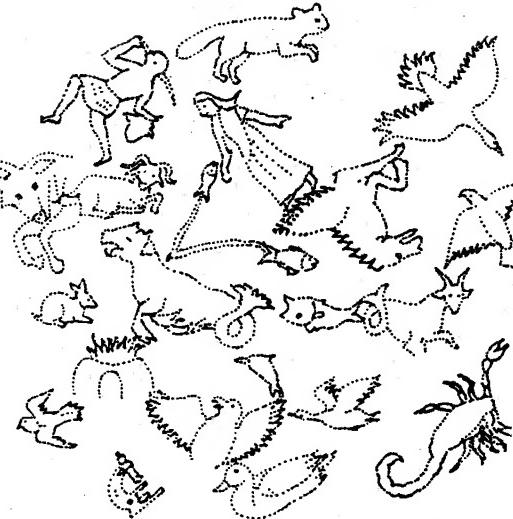
The sky picture at 8 o' clock in one month repeats at 6 O' clock the next month. Every month the earth crosses nearly 30° in its orbit around the sun. Accordingly the stars in our sky appear to have changed their positions to the same extent. It takes the stars 4 minutes to cover one degree in the sky. Hence in the whole month it moves up 30° up in the sky and appears before 120 minutes or 2 hours. It keeps on repeating this change of 2 hours throughout the year. That is why after one year we find the exactly similar sky picture in a particular time.

The real pleasure of watching the starry sky can be achieved by watching and feeling rather than reading and imagining. This can be increased manyfolds if one can have a binocular or a telescope to look through. A binocular resolving the sky objects 6 to 10 times makes the sky very attractive. But a telescope magnifies more than 20 times at least and makes it very illuminating and enhancing. A whole new universe is unfolded in the telescopic glass with lot more beauty and splendour than to the naked eye. The ring of Saturn, the craters of the Moon, the phases of venus, the dancing moons of Jupiter or watching the different galaxies, nebulae and other celestial bodies are something extremely special. One should get at least one chance to look at these great beauties of the sky through telescope in her/his life. Besides these the other attractions of the sky are phases of the moon, the full moon, the new moon, the Lunar and solar eclipses, the comets, supernovae and different types of stars.



SKY- AN UNENDING STORY BOOK

Ancient humans lived more close to nature than us. They observed the stars and plants more curiously to study their behaviours and positions in the sky. The stars were actually clock and calendar to them. All their activities were designed according to the position of stars only. Early humans grouped stars to make many patterns in the sky. They were the shapes of their observation and imagination. The different shapes referring to different animals, birds, objects, heroes and heroines. This made the sky more lively and talking. The appearance of different stars and constellations reminded them to plough, sow, harvest, hunt, fish, and celebrate different festivals.

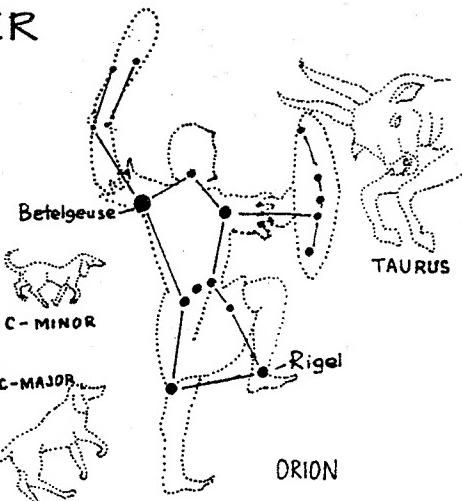


Stories were associated with each constellation. They were repeated through generations by all types of people. In India we are familiar with the sky stories accepted from the Puranas, Myths and lores. In European culture, the stories are derived from Greek, Romans, Arabs and persians. Each country further has many stories behind each constellation. If one gets fascinated by them and starts searching for more and more, the sky turns out to be an unending story book and the life appears too short to enjoy all.

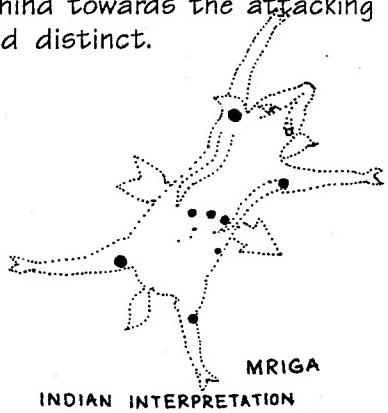
The common belief of "love conquers all things" applies strongly to the stars. Once one falls in love with the starry sky it turns out to be extremely exciting and rewarding. The habit becomes a noble hobby; Let us look at some of the popular constellations out of the 88 and find out the sweet stories behind them in different regions.

ORION, THE HUNTER

Orion is one of the most attractive constellations in the winter sky. The three stars at its middle queue up like soldiers and form the belt of the hunter. Above it we find a reddish glowing star named Betelgeuse, the right shoulder of Orion. The left shoulder is Bellatrix. Above these we see the head with a faint group of three stars. Below the belt we find the left foot of Orion in Rigel, a bluish-white star. On the opposite side Saiph represents his right foot. A sword also hangs from the belt downwards in form of M-42 nebulae.



A line drawn through its belt stars downwards leads to the brightest star in the sky - Sirius, the eye of one of Orion's dogs. The line drawn upwards leads to red star Aldebaran, the fiery eye of the attacking Bull (The Taurus). Halfway between Orion and the Bull we can also see a curve of faint stars referring to Orion's shield or lion's skin. Orion's right shoulder also looks like carrying a club. Overall, it looks like a strong man moving with 2 dogs from behind towards the attacking bull from the front. It looks fantanstic and distinct.

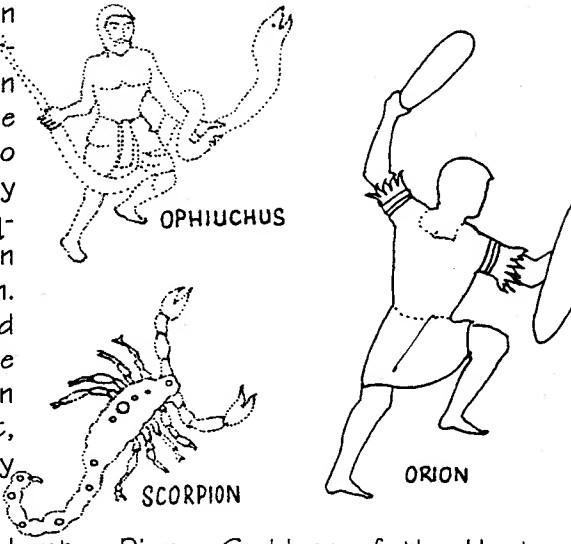


Orion, it is said, was the son of Neptune. He was so big and strong and handsome. He was so tall that he would walk through deep water without wetting his head even. He never feared any animal. Once he even threatened to exterminate all animals from earth. Gaia,

Jewels in the sky..... 37

the goddess of the earth, became furious. She sent a scorpion to kill Orion. The scorpion bit Orion. He fell to earth wounded.

In the real sky, when Orion sets in the west, scorpion rises at the sametime in the east. The next night the giant rose again, restored to health and strength by Ophiuchus, the Doctor of Antiquity. In the sky, when scorpion sets, ophiuchus stands over him. This means that he trampled him under his foot and gave Orion the antidote. Later when Ophiuchus sets in the west, Orion comes up in the east, fully recovered.



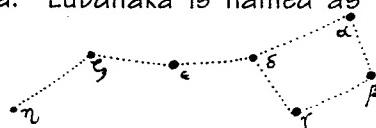
Orion was a handsome hunter. Diana, Goddess of the Hunt fell in deep love with Orion and did her best to draw him nearer to her. Diana was not the only one competing for Orion's attention. Aurora, the Goddess of the Dawn, also pursued Orion with her love. Orion seems oblivious to the advances of these two goddesses as he moves across the winter sky. When Orion sets in the west, however his stars fade very slowly, which means that the Dawn tries to stay by his side as long as possible. When Orion eventually leaves the scene, Aurora weeps bitter tears, which we can see on the flowers, grass and trees in the morning as drops of dew.

In another greek story Orion is described in a different way. The ancient Egyptians believed Orion to be Osiris, the god of light. After the Big Dipper, orion is perhaps the next most celebrated constellation of the winter sky. Poets have sung its beauty in numerous ways.

There are many stories about this constellation in different countries. In Hindu tradition, Prajapati (Brahma) had a beautiful

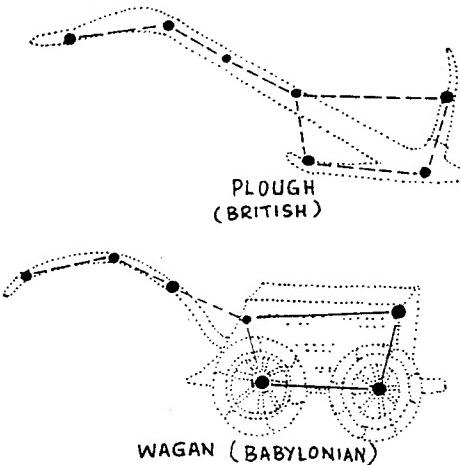
daughter named Rohini (in Taurus). Rohini romped around in the guise of an antelope. The father followed her as a deer without revealing his identity. This deer is named as Mriga. Rohini ran across the sky with Mriga following her. Lubdhaka, the Hunter however saw what was happening and shot an arrow at Prajapati which transfixes him forever to the sky where he now stands helplessly between Rohini and Lubdhaka. Lubdhaka is named as Mriga vyadha.

The Saptarshi

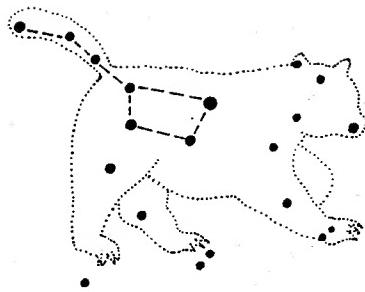


This is one of the oldest and most commonly known of all constellations. It is known in different names. Some of its common names are Ursa Major, Great Bear etc. other than Saptarshi. It looks like seven stars in form of a question mark yet a minute observation finds 227 stars. The seven prominent stars are Dubhe (α), Merak (β), phecda (γ), Megrez (δ), Alioth (ϵ), Mizan (ζ), and Benathnaseh(η). Merak and Dubhe are called the pointer stars, a line drawn through these stars to north leads to the Polaris. The other way it touches Leo.

In another look, the seven stars look like a saucepan with a long handle. These are called Big dipper by Americans, known as a plough to the British, Saptarshi to Indians, and Great bear to ancient Greeks. The Babylonians saw a wagon in Ursa Major; the short of wagon used to carry supplies for soldiers on the march. Egyptians placed a bull's hindleg in these stars. The Romans saw seven oxen in these stars. The Chinese of the third millennium B.C. and after saw in the stars of Ursa Major the god of literature. The American Indians have developed several bear stories.



One of these takes place in an oak jungle. They were mobile like animals. They used to go around after every midnight. They would visit each other, talk and come back to their original place before sunrise and stand stagnant. One day, a bear lost its way in that forest. After midnight all the trees started moving. The bear could not find a way to come out of the forest. The movement of trees was a new phenomenon to him. He collided with one oak tree by mistake. But he did not beg apologise for his mistake. He took it lightly. But a proud oak tree got furious at this incidence.



URSA MAJOR - GREAT BEAR

Indignant at his impoliteness, the oak began to chase the bear. Seeing this the bear started to run as fast as he could. In the deep of night a fantastic marathon took place, but the tree was not quick enough to catch the bear. This chase went on until dawn was near, at which time the tree was supposed to go back to its own place lest the sun god should notice its absence. Furious that it had not been able to catch the bear, the tree made a last effort and reached for the bear with all its might. By stretching its longest branches it just managed to grab hold of the bear's tail. With a ferocious swing the tree tossed the bear into the sky. The bear soared all the way to the dome of Heaven, where it can now be seen as the Great Bear.

The aztecs saw the stars of Ursa Major as their god Tezcatlipoca, who the Mayas called Hurrican from which comes the modern word Hurricane.

The interpretation of the 14 stars of the Great Bear and Little Bear has become a famous Dutch nursery rhyme; the English

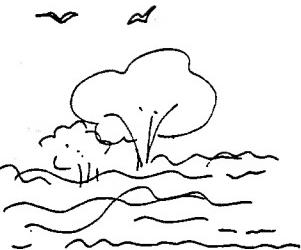
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translation is as follows:

"At night when I lay myself to rest
Fourteen angels for me do their best



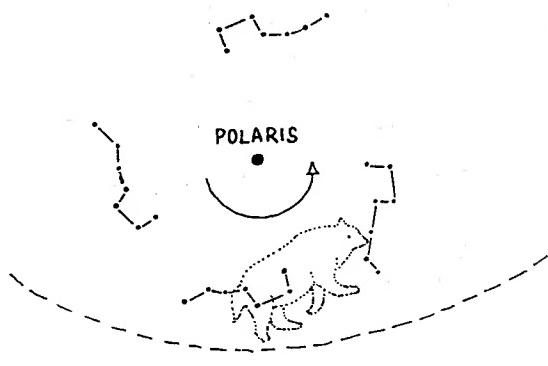
Two by my right hand
Two by my left hand
Two at my head-end
Two at my feet-end
Two who will cover me
Two who will awaken me
Two who will show one
To Heaven's Paradise."



The theme of the Great Bear

This relates to two simple facts of Nature. First, the Bear is a quadruped, but is able to stand upright on two legs and move about like a human being. Much mythological significance has been ascribed to this similarity between the posture and movement of humans and bears. Second, the daily circumpolar movement of Ursa Major is simple, easy to observe and can be imagined readily as similar to the shifting movement of a bear changing regularly from quadrupedal to bipedal to quadrupedal posture. As Ursa Major makes its daily transit around the pole star, it gives the appearance of a bear running on all fours when it is near the lower culmination of its transit. However, a few hours after the lowest culmination the quadrangle gradually rises into an upright position, just as a real bear would do as it stands up in its cumbersomeway.

URSA MAJOR



CIRCUMPOLAR MOVEMENT OF URSA MAJOR

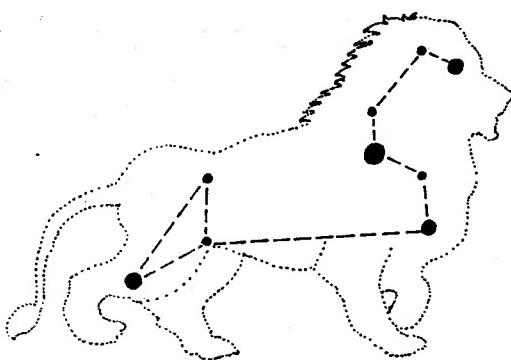
LEO -THE LION

Leo is a prominent constellation in the Spring sky. Its outlines are so nearly like that of a lion that the star hunter will not have much difficulty in finding it.

At the time of Claudius Ptolemy, Leo was seen as an enormous animal. At that time stars of the cancer constellation were also incorporated in Leo. An old Babylonian story tells of two lovers. The Babylonians saw a Great Dog in the stars of Leo. The Chinese saw several constellations in the area of Leo.

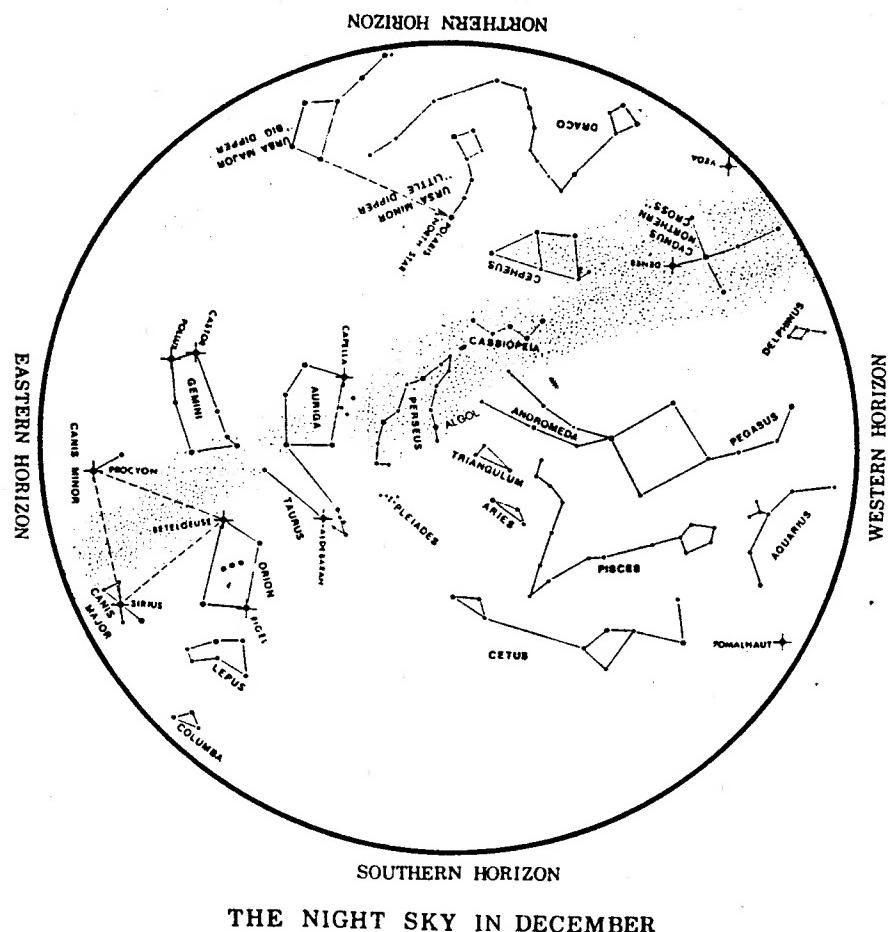
These are few examples of human's way of looking at the sky and interpretation. There are plenty of stories about each constellation in different places all over the world. Even in our small villages most people know many stars and constellations and narrate different stories. This is so fascinating that one forgets totally about herself/himself while looking at it. Sky is an open laboratory for all types of people, young or old, rich or poor, lettered or unlettered. We do not require much money to read the basics of the sky. Naked sky watching even can help in raising tremendous enthusiasm and inquisitiveness. A binocular or a telescope can definitely enhance one's appreciation and understanding.

But very unfortunately it has not found its due place in our text books. Whatever has been written in our textbooks on astronomy never tempts a child to come out and enjoy the night sky, rather forces to byheart the terms mechanically for an useless ex-



LEO

amination. Hence the more educated in the society have least idea about the sky and stars. Rather most of them believe on the negative and irrelevant side of Astronomy i.e., Astrology. This has neither any scientific base nor any authenticity. But an ordinary, uneducated villager identifies most of the stars in the sky, and enjoys their beauty and characteristics.



WHY THE SKY IS BLUE

PROF C. V. RAMAN

When I was asked to choose a scientific subject for my lecture I had no difficulty at all in choosing the subject of "Why the sky is blue." Fortunately, nature has been kind today; as I look up and see, the sky is blue; not everywhere, as there are many clouds. I chose this subject for the simple reason that this is an example of something you do not have to go to the laboratory to see. Just look up, look at the sky. And I think it is also an example of the spirit of science. You learn science by keeping your eyes and ears open and looking around at this world.

The real inspiration of science, at least to me, has been essentially the love of nature. Really, in this world, wherever we see, we see all kind of miracles happening in nature. To me, everything I see is something incredible something absolutely incredible. We take it all for granted. But I think the essence of the scientific spirits is to look behind and beyond and to realise what a wonderful world it is that we live in. And everyting that we see presents to us not a subject for curiosity, but a challenge, a challenge to the spirit of man to try to understand something of this vast mystery that surrounds us.

Science continually attempts to meet this challenge to the spirit of man. And the great problem today, which Dr. Sarabhai has addressed himself to, is how to rouse the younger generation of our country to meet this great challenge before us, once again to build up India into a great centre of knowledge



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and learning and endeavour. Well, I wish you all success. Now let me turn back to my problem "Why the sky is blue"

I raised this question because it is an easy subject. I only have to look up and see that the sky is blue. But why is it blue? The interesting point is that it is easy to answer that question in a casual way. If you ask a Botanist, why are leaves green? He murmurs, 'Chlorophyll'. Finished. You see, all scientific questions can be disposed of in that summary fashion, in one or two words. You can surely pass your examinations with that kind of answer, but that is not the real answer. As I said before, the scientific challenge of nature is to think, not only to discover but to think, to think continually and to try to penetrate this mystery: "Why is it blue?"



That is a very interesting problem, because two things are there. The sky is there and I am here. I see it is blue. It is the human brain and the human mind as well that are involved in this problem. Now suppose we put this problem before the young people. Don't read any book about it, don't ask your teacher.. Let us sit down and try to think out this problem: why is the sky blue. Look at it as if it is a completely new scientific problem about which

nobody has troubled himself before.



You sit down and think it out and you will find it is a most exciting thing to ask yourself, that question and see if you can discover the answer

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yourself. Now I will put it to you in this way. The best way to answer a question is to ask another. At night, we all see the stars. On a fairly clear night you see the stars twinkling in the sky. Why are the stars not visible in day time? Please ask yourself this question. Well, the reason obviously is that the earth, as modest a lady, has hidden herself under a veil. The sky is a veil which she has thrown around us. We cannot see the stars during the day, because the veil hides the stars. And what is this veil?

The veil obviously is the atmosphere of the earth. The same veil which at night is so transparent that we can see the faintest star and the milky way, is covered up in day-time. Obviously, it is the atmosphere which is the veil. And we see the sky as blue only because we have not got other thicker veils like these clouds. You see for example, those clouds high in the blue sky. Obviously therefore, for the sky to be really blue, there must be nothing else, no clouds and perhaps no dust. The clearer the sky is, the bluer it is. So the sky is not always blue; it is sometimes blue and sometimes not blue at all. So that the mere looking at the sky enables us to understand the condition of the atmosphere.

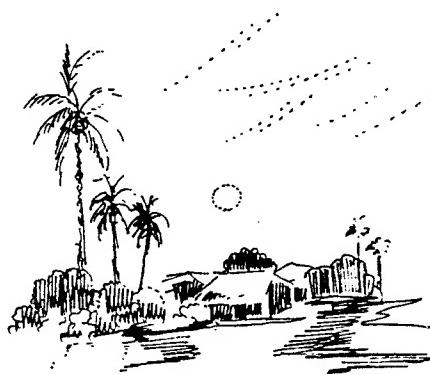
Let me say one thing more. Obviously, the sky and the atmosphere are lit up by the sunlight. Sunlight is passing through this great column of air and obviously it is the atmosphere, something that is transparent and invisible at night, that is seen to us by the light sunlight-passing through the atmosphere. Now I want you to ask yourself another question.

I don't know if any of you have had the curiosity to look at the clear sky on a full-moon night: You know that moonlight is only the sunlight incident on the moon and is diffused or reflected. I

don't know if any of you have really watched the sky on a clear full moon night. You will be astonished to find that the sky is not blue. It appears pale, you just see some light and you see some of the stars even under the full-moon sky, but the sky is not blue.

Why is it that the sky which appears blue in sunlight, does not appear blue in moonlight ? The answer obviously is : the illumination is far less powerful. You don't require to be much of a mathematician to calculate the ratio of the intensities of full-moon light and sunlight. I present it to some young mathematician to sit down and work out. How big is the moon ? What should be the brightness of moonlight ?

It is a little astronomical problem. Rough arithmetic would tell you that a moonlight is something like half a millionth part as bright as sunlight; you would think, it is terribly small. But moonlight, when, it is there seems very bright though it is only half a millionth part of the brightness of sunlight. Why does it look so bright ? Well, the eyes have got accustomed to much lower levels of illumination. So moonlight appears very bright but not so bright, as to veil all the stars. But the sky, it does not appear blue. So this comparison of sunlight and moonlight brings to our notice a very remarkable fact.



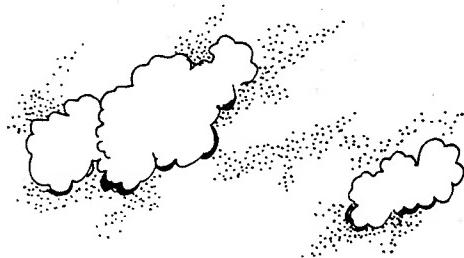
It is an absolutely fundamental aspect of human vision that to perceive colour you must have a high level of illumination. The sky is blue, merely because sunlight is brilliant; moonlight is much less brilliant and so you don't perceive colour. This is a principle which perhaps is not so widely appreciated as it ought to be. Colour is only perceived at high levels of illumination. The higher the illumination the brighter are the colours. You go down to low levels of

illumination, say, a millionth part, half a millionth or a hundred thousandth part of sunlight, the sense of colour disappears. Now this is a very fundamental fact of human vision, which simply comes out of nothing else but just observation and thinking, that's all.

I can go on giving any number of illustrations. Perhaps the most striking illustration emerges when you look at the stars or such objects as the Orion nebula through small telescopes. Let me say here and now, my belief that there is no science so grand, so elevating, so intensely interesting as astronomy. It is amazing to see how many people high up have never seen the sky through the telescope. I want to tell them something which is absolutely incredible : Nothing more than a pair of binoculars, a good pair of binoculars is needed to educate oneself in the facts of astronomy.



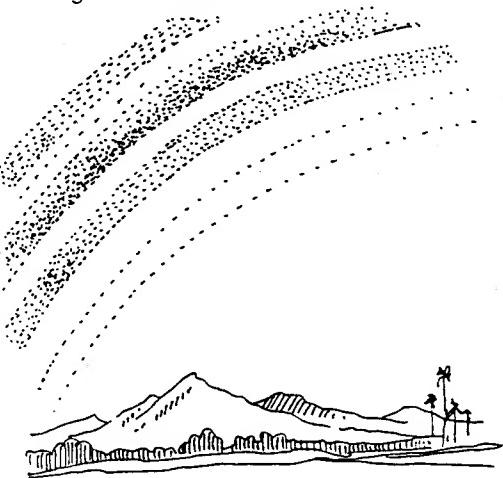
I think a man who does not look at the sky even through that modest equipment - a pair of binoculars - cannot be called an educated person, because he has missed the most wonderful thing and that is the universe in which he lives. You must have a look at it. You don't see much of it, but you see a little and even this little is enough to elevate the human soul and make us realise what a wonderful thing this world is.



I come back now to the problem of the blue sky. I want to pose to you a very difficult question. Why is it that we perceive the blue colour only under intense illumination in sunlight, and not in moonlight?

I will by-pass that and come back to the question: Why is the sky blue ? Well, we all know that white light is composed of all the colours in the spectrum. You divide white light into various colours; you start with deep red at one end, light red, orange, yellow, green, blue and violet, so on, the whole range of colours.

When I look up at the sky, I see only the blue; what has happened to the rest of the spectrum ? This is the basic question. The question becomes a very pressing one when I remark that when we actually spread out sunlight into a spectrum, the blue part of it is the least intense part. Less than 1/40th of the whole energy of the brightness of the sunlight appears in the blue of the spectrum and we see only that 1/40th part. You don't see the rest of the spectrum. It has simply vanished. It is not there at all. You can look very very hard and try to see if you can see any red or yellow or green in blue sky. We don't see it. The blue has just masked the rest of the spectrum. This is a very remarkable fact.



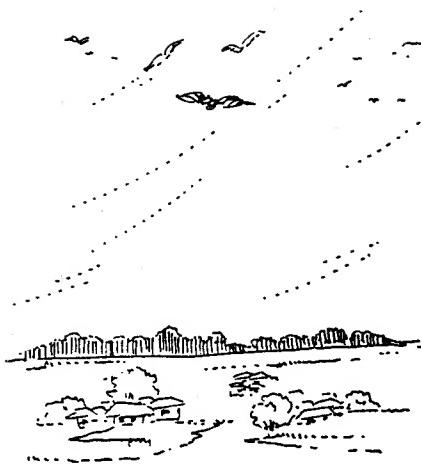
If you watch the sky on some occasions, you get great masses of white clouds, what they call, the cumulus clouds not huge things, just little bunches. It is a beautiful sight to see the blue sky and these little masses soaring above. I have derived great satisfaction in just doing nothing at all and looking at these masses of clouds and the blue sky.



The interesting point is precisely when you have the clouds moving about that the sky is bluest. What it means is that these cumulus clouds in

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the course of their formation just cleaned up the rest of the atmosphere. They take up the dust particles and concentrate them on the white clouds. The rest is left nice and clean. You see the beautiful blue view against the brilliant white, it is a very lovely sight. A sight for the Gods, only you don't bother to look at it because it is so common. You may ask me, how is the cleaning process accomplished? Now here is a wonderful story. When I ask the young people, "what is the cloud?" "Oh! sir, it is steam". The usual answer you get is that the cloud is steam, but it is nothing of the sort.



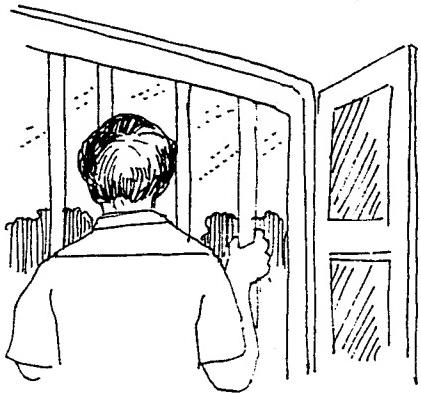
The cloud consists of particles and what looks to us as great masses of white clouds are just droplets of water. Water is heavy but why does it not fall down? We find it floating in the air; You see that is another problem. Already I am going from one problem to another. We ask ourselves, what is cloud? Why is it floating in the air? The moment you ask the question, "Why the sky is blue?" You go deeper and deeper into some of the deepest problems of physics. Now the interesting point is this you cannot have a cloud unless you have dust particles about which it can form. There must be particles of some sort, may be very small, may be very large. They call it in learned language 'Nuclei'.



If there is no dust in the air there will be no cloud and no rain. You see, how from the blue sky, we have got on to the origin of rain, rainfall and so on. One thing leads to another. That is essence of science. You

must go deeper where it leads you. You cannot go thus far and no further. The moment you raise a question, another question arises, then another question, so on and so on. Ultimately, you find that you have to travel the whole field of science before you get the answer to the question: Why the sky is blue? So I told you this fact about the clouds. Well, I should say the cloud cleans up the atmosphere.

Cloud forms and then leaves the atmosphere clean, comparatively free from dust particles and other nuclei and that is why the sky is blue. So we come down at last to getting some kind of answer to the problem. The sky is blue because the atmosphere is clean and free from dust and all nuclei. The clearer it is, the bluer it looks, provided there is enough light. So you come somewhere near the answer to the question. What is it you are able to see? The fact is that when we see a blue sky, we see the atmosphere of the earth, the gases of the atmosphere, they diffuse the light and we see the blue light of the sky. But still we are far from the answer.



I told you that blue is only 1/40th part of the sunlight. What happens to the rest of the light, the sunlight? That is the question. Now this question can be answered in the following fashion. You look at the white cloud and look at the blue sky. You can compare them with the help of a pocket spectroscope and you find strangely enough that you have to look very very carefully before you find any difference in the spectrum of the blue sky and the spectrum of the white cloud.

White cloud is certainly very much brighter. But so far as spectrum is concerned, you see in the blue sky and in the cloud the same spectrum. It also starts with the red end and goes on till

the blue. But in one case you see the blue, in the other case you see the white. And with great trouble, you look very carefully; you see that there is some difference in the relative brightness. You can see the yellow and the red, not so bright relatively. Mind you, it is a mental calculation.

You see the relation of brightness between the blue part of the sky, the blue part of the spectrum and the violet part and the rest of the spectrum. Relatively to the red, the yellow and the green, the blue and violet are stronger in scattered light in the diffused light of the blue sky. Still you are very far from the answer. It does not explain why don't we see the rest of the spectrum.

Actually in the blue sky the green and the yellow and the red are still there, they are still far brighter, perhaps not so perhaps not 40 times but perhaps ten times brighter than the blue. Then why do we see the blue and why don't we see the rest? Here again you come across an extremely difficult question to answer. The actual brightness of the blue part of the spectrum.

Now this is very simple and very surprising. But there is a nice little experiment which, perhaps one day, will be shown at the Science Centre which will enable you to see at least that it is not an exceptional phenomenon. It is one of the most fundamental facts of human vision that the blue part of the spectrum inspite of its weakness dominates the spectrum in certain conditions and plays a role tremendously far more important than its actual brightness warrants. Now the experiment is the following:

It is a very easy experiment. You take water and put a little copper sulphate in it and then put excess ammonia in it. You will get a solution called cuprammonium. If it is very strong it will transmit only



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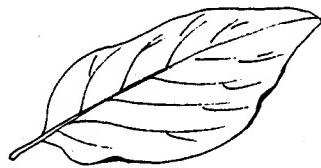
deep violet light. Put it in a cell. You go on adding water in the cell and look at the colour of the bright lamp and see that the following thing happens. The deep violet changes into blue. The blue changes to a lighter blue and so on. But till the very last, it remains blue. In the spectrum of the light the solution is transmitting red light, green light, not of course yellow. Lot of light comes through the spectrum and the blue is still only a minor part of the whole.

Whatever light comes through the spectrum you cannot see and you cannot even imagine any other colour coming through. And the reason for it is as follows. If you examine the transmitted light through a spectroscope you will find that the yellow part of the spectrum is diminished by the influence of cuprammonium. It absorbs and cuts out the small part of the width of the spectrum.

But a very important part and that very important part is the yellow of the spectrum. Never mind how it absorbs the yellow part and controls the colour. The light is blue simply because the yellow is absorbed and blue comes into vision. If you take the whole spectrum and if you reduce the strength of the yellow part of the spectrum at once you find the blue part of the spectrum and the blue colour dominates.

This is again a fact of physiology. If you want any colour what so ever to be showy, you must take out the yellow. Take for example that red carpet, which has been spread in my honour, I suppose. You look at it through a spectroscope. I can tell you beforehand, there will be no yellow in it at all. To get any colour, red, green or blue, you must take out the yellow. Yellow is the deadly enemy of colour. All other colours I mean.

Look at the green leaf. All the leaves are green, not because of the presence of chlorophyll -the chlorophyll has a

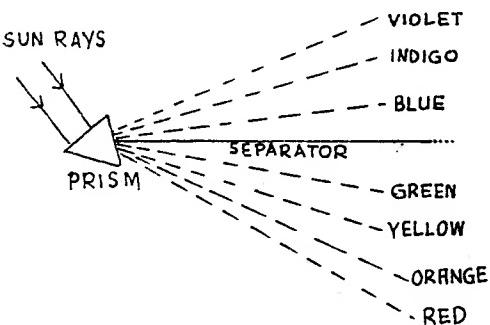


strong absorption of red no doubt. But the real factor which makes the colour green is the fact that the yellow is taken off. Chlorophyll has enough absorption of the yellow to reduce the strength of yellow. Well, I examined silks for this. Bangalore is a great place for silk manufacture. I managed to purchase about 25 30 blouse pieces. I got them to verify the proposition that all brilliant colours require the suppression of the yellow region of the spectrum. Look at the rice field. It is wonderful. Look at the rice field with a spectroscope.

It looks very much like the spectrum of the blue sky. But the only visible difference you can actually see at a glance between the blue sky and the green rice field is that the blue part of the spectrum has been cut off and that is produced by the so-called carotenoid pigments that are present here, which cut off the blue; the rest of the spectrum looks almost alike.

But if you look very carefully, you will see that in the colour of the rice field, you do not get the yellow. The removal of yellow is essential, before you can perceive the leaves as green. You see always this predominance of the yellow. On the contrary if the yellow is taken off, the blue dominates. If you don't take off the yellow, the yellow dominates.

The two are contradictory and they are enemies to each other. The fact is that you can divide - the physical explanation is deeper still - you can divide the whole spectrum into two parts. The division is just where the blue ends; that part of the spectrum extending to green, yellow, orange and red amounts only to yellow. The other parts of the spectrum summed up amounts to blue. Now if you take off this or reduce this you get the other. This is the real

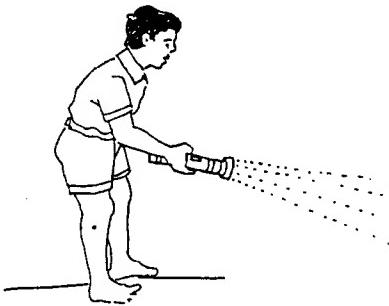


explanation of the blue colour of the sky and is very significant. You reduce - not that you abolish - the intensity of the yellow in the spectrum and of course of the green and the red. It is the reduction of the yellow of the spectrum that is to say the predominance of the blue which is responsible for the blue light of the sky. Well, one can carry further and say that it is the reduction of yellow that is basic. And why is it reduced?" "Oh, the scattering of light by the molecules of the atmosphere."

I could have dismissed the whole lecture in one sentence. I could have said just as the botanist says "why is it green?" "Just chlorophyll." I could have said "why is the sky blue?" "Scattering of light by the molecules of the atmosphere." One sentence, "Then sir" you would ask me, "why all this lecture?" Because, my young friends, I want you to realise that the spirit of science is not finding short and quick answers.

The spirit of science is to delve deeper - and that is what I want to bring home to my audience - and deeper. Don't be satisfied with the short and ready quick answers. You must never be content with that; you must look around and think and ask all sorts of questions; look around the problem and search, and search and go on searching. In the course of time you will find some of the truth, but you never reach the end. The end, as I told you, is the human brain, but that is very far away yet.

This is the spirit of science. I should give you an illustration of how by pursuing a simple question, I can go on talking to you as if I have just begun, the real subject of my lecture : "Why the sky is blue." "The sky is blue because the illumination of the sky light is due to the scattering of light by the molecules of the atmosphere". Now this is a discovery which came rather slowly. The person who



first stated this explanation was the late Lord Rayleigh.

I think that dreams are the best part of life. It is not the realisation, but the anticipation; I am going to make a discovery tomorrow, that makes a man of science work hard, whether he makes the discovery or not. And this is what I want to emphasize once again. Science is essentially and entirely a matter of the human spirit.

What does a poet do? What does a painter do? What does a great sculptor do? He takes a block of marble, chips, goes on chipping and chipping. At the end of it, he produces the dream in the marble. We admire it. But, my young friends please remember what a tremendous amount of concentrated effort has gone in to producing that marble piece. It is the hope of realising something which will last forever which we will admire for ever that made him undertake all that work.



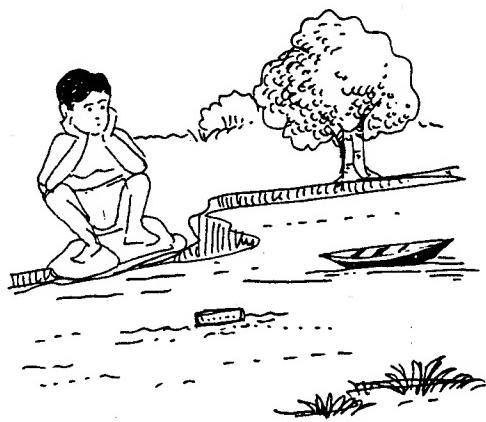
Essentially, I do not think there is the least difference whatever between the urge that drives a man of science to devote his life to science, to the search for knowledge and the urge that makes workers in other fields devote their lives to achieving something. The greatest thing in life is not the achievement but it is the desire to achieve. It is the effort that we put in that ultimately is the greatest satisfaction.

Effort to achieve something is the hope of getting something, let it come or not come, but it is the effort that makes life worth living and if you do not feel the urge towards the search for knowledge, you can never hope to be a man of science. You can perhaps get a job in some of the departments, get a nice comfortable salary, in which you do not have to do any thing except to wait for

the monthly cheque, but that is not science. The real business of a scientific man is to try to find something real and to look forward to the acquirement of knowledge.

Having said all this, may I again come back to the blue sky? I have not finished yet. In fact, to tell you the honest truth, I have only just begun my lecture. "Why is it that the molecules of the air scatter light?" The obvious thing is this, as I told you, the long waves in the spectrum - I am using the language of wave optics - the long waves of the red, yellow and a green are scattered less in the diffused light and the rest quite strongly, with the result that the eye perceives this and not that.

Now why is that? The answer is very obvious. The molecules of the atmosphere are extremely small in size, incredibly small compared with what is the standard of comparison, the wave length of light. The same thing you notice, for example, if you look at a big lake. The wind blows on the waves and you have a piece of cork or wood floating on it. You see the wood trembling. Why? Because the size of the wood is comparable with the size of the waves. But suppose you had a big boat going on the lake; I do not know how big the boat can be, but you see that the big boat is not disturbed so much as the small particle.



It is the relationship between the size of the disturbance and the size of the particle that determines the effect the waves produce on the particles and vice versa, the effect produced by the particles on the waves. This is the basic principle which results in the scattering of the shorter waves by preference. You can show that by any number of experiments in the laboratory; for that, you don't require molecules of air. You require just some water and put

in it some substance like bit of soap. You can also make the experiment with smoke; particles small enough will scatter the shorter waves by preference. But you don't get the real rich blue colour unless the particles have adequate illumination.

Unless the illumination is strong enough, the sensation will be just the palest of pale blues. Now I have come from the scattering of blue sky to the study of molecules. And there the subject begins and it goes on. In fact I started the subject in the year 1901.

What I told you was known pretty well except the vision part of which I have spoken about. That is my most recent work, but what I spoke about molecules and so on was all known in 1921. At that time, we thought it was finished. Today, we know that the faculty of vision and the quality of vision lay an immense role in the subject.

The subject of my lecture is not the blue of the sky, but as you must have all understood by this time it is the spirit of science. What is science? And how can we in this country hope to advance science? How can we try to really make ourselves worthy of our ancestors in the past? That is the real topic of my lecture. It is only the peg to hang the subject upon.

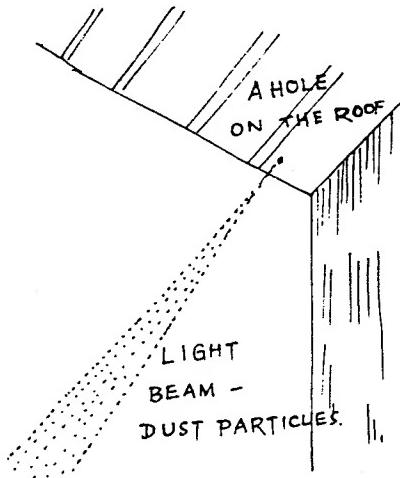
Well the story begins there. The question is how does light interact with molecules and what happens with molecules and what are molecules and so on. Science never stops. It is going on. The more you find, the more appears that you have to find. That is the attraction of science, provided you are not distressed too much by other people getting in front of you. Don't bother about them. The



real point is that it is an endless quest and every new discovery opens new paths for discovery. New questions arise requiring new answers.

But then, I cannot give this lecture without making some reference at least as to how all this I am talking about is united up with metereology all the time. But the real interest in the subject is not in metereology at all. The real interest in the subject is the scattering of light which is the most powerful weapon we have today for understanding the ultimate nature of the molecules of the air.

You can count the molecules. You can make the experiment which every student of science ought to have seen. You take a glass bottle, a flask and a cork and get all the dust out of it and send a beam of light, it may be sunlight, it may be any thing else but see that the beam of the light goes through the air. You can see the air. The air is not such a transparent, colourless gas; it is not invisible. You can make air visible by means of this scattered light.



This is a very simple experiment and ought to be seen by every student of science at least once in his life time. You can see air. You can see any gas. You can see any vapour by the strength of the light diffused by the individual particles. And the more particles you have, the stronger the diffusion. From the strength of the diffusion, you can actually count the number of molecules. I use the word counting, not like one, two, three, four; it is a sort of different type of counting.

When I was in the currency office, they used to count the rupees. You know what they did; they weighed the bags; each bag

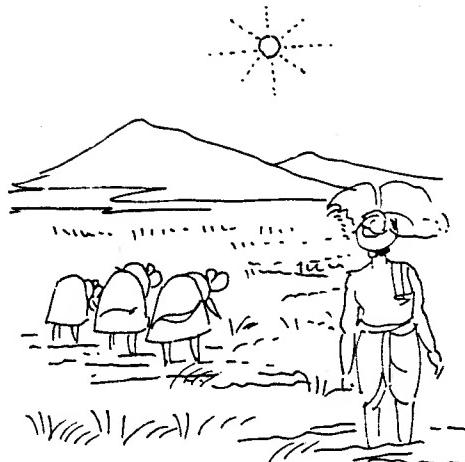
was supposed to contain 2,000 rupees - that had to be taken or trust - and then multiply the number of bags and you get a crore of rupees. Like that, you count the molecules of the atmosphere. It is only a sort of estimate. But more than that, we can actually see the scattering of light simply by looking through an instrument; you can find out whether a molecule is short or long, whether it is spherical or tetrahedral shape and so on. The study of the blue sky is an immense field of research, an unlimited field of research, which was opened up and is still being pursued.

The quest, you see, is the more the deeper you go. Then the question arises what about light ? I cannot possibly enter into all that. Because, my idea as I told you is just to give you a simple glimpse into how a familiar phenomenon is linked up with deeper problems of Physics and Chemistry. That is the lesson we learn today. From the familiar fact, it is not necessary to hunt round the textbooks to find problems of science.

You keep your eyes open and you see that all round you the whole world bristles with problems to solve; but you must have the wit to solve it; and you must have the strength of mind to keep going at it until you get something.

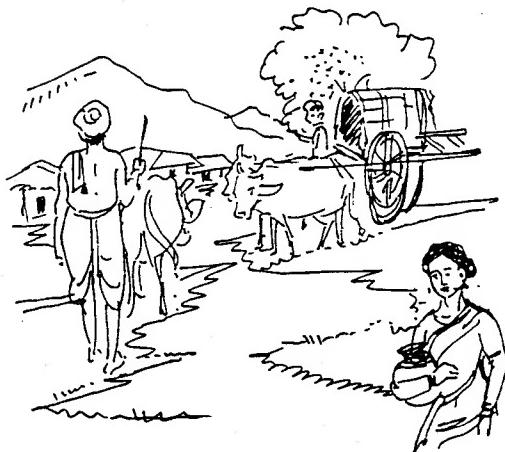
This is the lesson which I want to bring home to the younger generation in front of me. What is the use of all this? Here again, I want to stress the philosophy of my life. Never to ask what is the use of all this. As I told you before, it is the striving that is worthwhile. Because we have certain inherent powers given to us to use - observation and thinking - we must use them. The more we use them, the sharper they become, the more powerful they become and ultimately some-





thing will come out of it so that humanity is benefited, science is benefited. Ultimately the aim of scientific knowledge is to benefit human life. And that comes automatically because the problems with which we are concerned in science are always those that lie nearest to hand. They are concerned with things about us.

So long as we deal with the problems which arise out of our environment, you never can say that any particular piece of work can be useless. The most important, the most fundamental investigations, though at first might seem an abstraction of nature, are precisely those, which in due course, affect human life and human activities most profoundly.



This is a very heartening thing because one should not think that scientific work in order to be valuable, should be useful. Scientific work is valuable because it will ultimately prove its value for the whole of human life and human activity.

That is the history of modern science. Science has altered the complexion of things around us. And precisely those scientists who have laboured not with the aim of producing this or that, but who have worked with the sole desire to advance knowledge, ultimately prove to be the greatest benefactors of humanity.

Advice to Youth....

You, our young men come to the Universities and leave them to face the world...a world which may seem to be an unsympathetic harsh world. I would like to tell the young men and women before me not to lose hope and courage. Success can only come to you by courageous devotion to the task lying in front of you and there is nothing worth in this world that can come without the sweat of our brow.

We have abundant human material in India. Speaking as a teacher of 24 years' experience, I can assert, without fear of contradiction that the quality of the Indian mind is equal to the quality of any Teutonic, Nordic, or Anglo-Saxon mind. What we lack is perhaps courage, what we lack is perhaps driving force which takes one anywhere.

We have, I think developed an inferiority complex. I think what is needed in India today is the destruction of that defeatist spirit. We need a spirit of victory, a spirit that will carry us on to our rightful place under the sun, a spirit which will recognise that, we as inheritors of a proud civilisation, are entitled to a rightful place on this planet. If that indomitable spirit were to arise, nothing can hold us from achieving our rightful destiny.



LIST OF CONSTELLATIONS

Latin	English	Latin	
Andromeda	(princess of Ethiopia)	Corona Australis	(Southern crown)
Antlia	(Air pump)	Corona Borealis	(Northern crown)
Apus	(Bird of paradise)	Corvus	(crow)
Aquarius	(Water carrier)	Crater	(cup)
Aquila	(Eagle)	Crux	(Southern cross)
Ara	(Altar)	Cygnus	(Swan)
Aries	(Ram)	Delphinus	(Dolphin)
Auriga	(Charioteer)	Dorado	(Swordfish)
Bootes	(Herds man)	Draco	(Dragon)
Caelum	(Chisel)	Equuleus	(Little Horse)
Camelopardalis	(Giraffe)	Eridanus	(River Eridanus)
Cancer	(crab)	Fornax	(Furnace)
Canes Venatici	(Hunting dogs)	Gemini	(Twins)
Canis Major	(Big dog)	Grus	(Crane)
Canis Minor	(lesser dog)	Hercules	(Hercules)
Capricornus	(Goat)	Horologium	(Pendulum clock)
Carina	(Keel)	Hydra	(Water snake)
Cassiopeia	(Queen of Ethiopia)	Hydrus	(Lesser w. snake)
Cetus	(Whale)	Indus	(Indian)
Chamaeleon	(Chameleon)	Lacerta	(Lizard)
Circinus	(Compasses)	Leo	(Lion)
Columba	(Dove)	Leo minor	(Little lion)
Coma Berenices	(Berenice's hair.)	Lepus	(Hare)

Latin

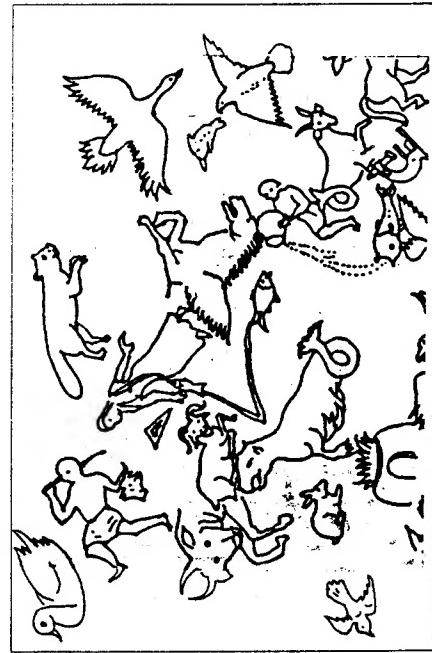
English

BRIGHTEST STARS NORTHERN HEMISPHERE

	Star	Constellation	Magnitude
Serpens	Arcturus	Boötes	-0.1
Sextans	Vega	Lyra	0.0
Taurus	Capella	Auriga	0.0
Telescopium	Procyon	Canis Minor	0.4
Triangulum	Betelgeuse	Orion	var
Triangulum Australe	Altair	Aquila	0.08
Tucana	Aldebaran	Taurus	0.8
(Southern triangle)	Pollux	Gemini	1.2
(Toucan)	Deneb	Cygnus	1.3
(Great bear)	Regulus	Leo	1.4
(Little bear)			
(Sail)			
(Virgin)			
(Flying fish)			
(Fox)			

BRIGHTEST STAR SOUTHERN HEMISPHERE

Sirius	Canis Major	-1.4
Canopus	Carina	-0.7
Alpha Centauri	Centaurus	0.6
Rigel	Orion	0.1
Achernar	Eridanus	0.5
Agena	Centaurus	0.6
Alpha Crucis	Crux	0.8
Antares	Scorpio	0.8
Spica	Virgo	0.9
Fomalhaut	Piscis Austrinus	1.2
Beta Crucis	Crux	1.3



GEO CALENDAR

Let us assume :

The age of earth : 480 years = 1 year .

Sl. No.	Changes	Original time (Crores years back)	Imaginary geo-scale
1.	Origin of earth	480	1 January
2.	Stone formation	400	1 February
3.	Origin of Life	380	1 March
4.	Old fossils	330	1 April
5.	Photosynthesis	260	Middle June
6.	Unicellular organism	140	Middle September
7.	Multicellular organism	80	1 November
8.	Invertebrates	60	Middle November
9.	Terrestrial plants.	40	1 December
10.	Dinosaurs, mammals.	25	Middle December
11.	Apes	5	27 December
12.	Humans	5 lakh years back	31 December

UNIVERSE — Yesterday to Today.

Time: 0



Big Bang

3 Minutes



Helium formed

10 Lakh years



Hydrogen Gas formed

100 Crores years



Galaxies formed

500 Crores years



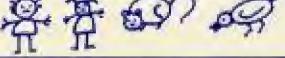
Stars formed

1000 Crores years

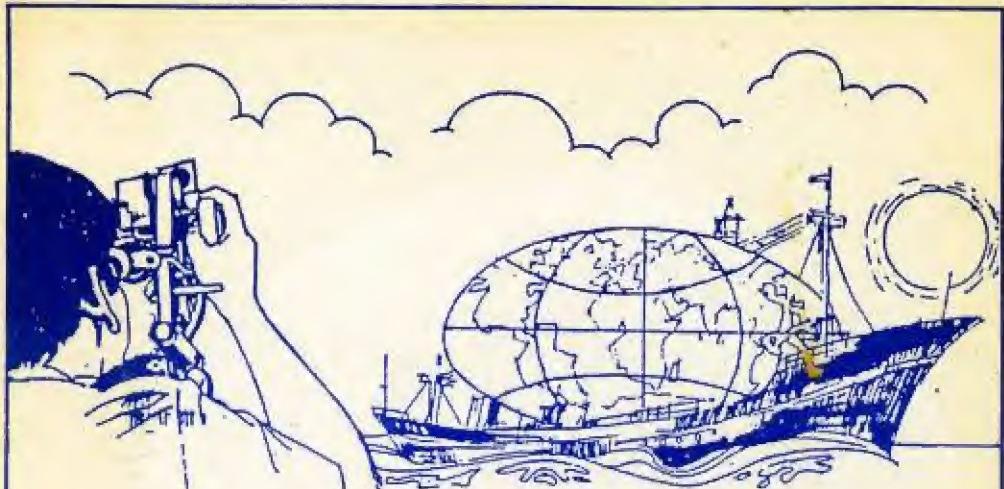


Solar system formed

1500 Crores years



To-day



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SAILORS ARE THE OLDEST ASTRONOMERS**

WE MAINTAIN THE TRADITION



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